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CONTENTS.

NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the Monthly Weather Review (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

Reprints are made up without covers in the original size and pagination of the Review. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Acting Editor.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1915. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belén College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

CORRIGENDUM.

In the REVIEW, April, 1916, page 198, col. 2, Table 2, *for* $D=\sqrt{\frac{S(X'}{n}-\frac{r^2}{n^2}}$ *read* $D=\sqrt{\frac{S(X')^2}{n}-\frac{r^2}{n^2}}$.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING MAY, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., June 15, 1916.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January and April, 1916, **44**:2, 179, 180.

On May 11, 1916, the Marvin pyrheliometer at Santa Fe, N. Mex., was removed from the office to a special shelter provided for it on the roof of the building, where exposure to the sun is possible at all hours of the day. In this shelter the pyrheliometer is 7,037 feet or 2,145 meters above sea level.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation averaged below normal at Washington and above normal at Santa Fe and Madison. At the latter station, however, there were few days when clouds were absent for a sufficient length of time to permit pyrheliometric measurements to be made.

A noon maximum of 1.61 gram-calories per minute per square centimeter of normal surface, obtained at Santa Fe on May 4, exceeds any previous May noon reading at that station by 4 per cent.

TABLE 1.—*Solar radiation intensities during May, 1916.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Washington, D. C.										
A. M.										
May 1	1.18		0.82							
6	1.34	1.18	0.95	0.78	0.64	0.54				
9	1.04	0.78	0.65	0.55						
10		1.08	0.99	0.83	0.68					
12	1.39	0.99	0.93	0.89						
17		1.23	1.02							
18	1.28	1.20								
19	1.36	1.26	1.15	1.06	0.99	0.93	0.83	0.75		
20	1.29	1.07								
21			1.18	1.03						
25	1.27	0.99								
26	1.26									
28			0.95	0.87						
Monthly means	**1.27**	**1.09**	**0.96**	**0.86**	**0.77**	**(0.74)**	**(0.83)**	**(0.75)**		
Departure from 8-year normal	**−0.05**	**−0.07**	**−0.09**	**−0.07**	**−0.07**	**−0.03**	**−0.01**	**+0.05**		
P. M.										
May 1		0.99	0.69	0.62	0.56	0.50	0.45	0.41	0.37	0.33
6		0.80	0.67	0.56	0.49					
12		1.16								
19		1.26	1.11							
Monthly means		**1.05**	**0.82**	**(0.59)**	**(0.52)**	**(0.50)**	**(0.45)**	**(0.41)**	**(0.37)**	**(0.33)**
Departure from 8-year normal		**−0.11**	**−0.17**	**−0.26**	**−0.23**	**−0.24**	**−0.22**	**−0.20**	**−0.22**	

TABLE 1.—*Solar radiation intensities during May, 1916*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Madison, Wis.										
A. M.										
May 5	1.35	1.34								
7	1.34									
11	1.40									
18	1.42	1.31	1.23							
31	1.33									
Monthly means	**1.37**	**(1.32)**	**(1.23)**							
Departure from 6-year normal	**+0.05**	**+0.11**	**+0.12**							
P. M.										
May 5		1.24								
11		1.33	1.20							
Monthly means		**(1.28)**	**(1.20)**							
Departure from 6-year normal		**+0.10**	**+0.24**							
Lincoln, Nebr.										
A. M.										
May 1	1.54	1.48	1.36							
3	1.53	1.43	1.35	1.26	1.17	1.08	1.01	0.93		
4	1.41				1.14	1.06	0.99	0.93	0.88	
5		1.34	1.22	1.12	1.04	0.96	0.89	0.79		
7			1.18	1.08	0.98	0.89	0.82	0.74		
8		1.33	1.18	1.04	0.92	0.76	0.64	0.53		
10	1.21	1.17	1.11	0.99	0.88					
17		1.42	1.37	1.27	1.19					
22		1.36	1.28	1.20	1.12	1.04	0.97	0.91		
23	1.41									
24			1.03	0.93	0.85	0.78	0.71			
25	1.39	1.26	1.14	1.01	0.86	0.79	0.72			
28				1.03	0.99	0.91	0.83			
30	1.39	1.24	1.08	0.96	0.87	0.81	0.75			
Means	**1.41**	**1.34**	**1.21**	**1.08**	**1.00**	**0.91**	**0.83**	**0.80**	**(0.88)**	
P. M.										
May 1		1.29		1.18	1.11	1.05	0.97	0.90	0.83	
3			1.19							
4		1.32	1.23							
5		1.32								
6		1.22	1.10							
24		1.11	0.96	0.84	0.73	0.66	0.59			
Means		**1.25**	**1.12**	**(1.01)**	**(0.92)**	**(0.86)**	**(0.78)**	**(0.90)**	**(0.83)**	
Santa Fe, N. Mex.										
A. M.										
May 4	1.62	1.52	1.43	1.36	1.30	1.24				
12	1.59	1.47	1.37	1.31	1.19	1.14	1.10	1.05		
13	1.53	1.42	1.33	1.26	1.20	1.17	1.14	1.06		
16	1.60	1.40	1.39	1.36	1.31	1.26	1.20	1.15	1.10	
18	1.51									
19	1.51	1.38	1.31	1.26	1.20	1.15	1.10	1.05	1.01	
22	1.51	1.46	1.40	1.33	1.24	1.21	1.12			
24	1.54	1.46	1.38	1.31	1.24	1.21	1.12			
25	1.58	1.47	1.40	1.34	1.26	1.19	1.16			
26	1.60									
27	1.62	1.50	1.39	1.30	1.24	1.19	1.13			
29	1.53	1.44	1.36	1.29	1.23	1.18	1.13			
Monthly means	**1.56**	**1.45**	**1.38**	**1.31**	**1.24**	**1.19**	**1.13**	**1.08**	**(1.06)**	
Departure from 4-year normal	**+0.03**	**+0.03**	**+0.05**	**+0.04**	**+0.02**					
P. M.										
May 15		1.50	1.44	1.37	1.30	1.23	1.17			
16		1.49	1.41	1.35	1.30	1.24				
24		1.39	1.26	1.12	1.11					
25		1.41	1.29	1.25	1.19					
26		1.45	1.38	1.33	1.23					
27			1.37	1.27	1.22					
Monthly means		**1.45**	**1.36**	**1.28**	**1.22**	**(1.24)**	**(1.17)**			

TABLE 2.—*Vapor pressure at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*
May 1	7.29	7.87	May 5	6.27	7.57	May 1	4.17	4.57	May 4	3.15	2.39
6	9.47	8.18	7	6.27	12.24	3	4.93	4.57	12	3.99	2.16
9	5.36	6.50	11	4.57	4.17	4	5.36	6.50	13	3.15	1.88
10	7.04	12.21	18	4.37	4.57	5	6.76	7.57	15	1.96	1.12
12	4.57	7.57	31	5.56	9.83	6	9.47	8.18	16	1.78	1.52
17	5.36	4.37				7	10.97	12.24	18	3.45	2.87
18	6.50	5.36				8	6.02	5.16	19	3.00	1.96
19	4.75	6.50				10	4.95	2.49	22	2.87	3.63
20	7.04	7.87				17	6.02	5.56	24	4.57	11.81
21	4.95	5.56				22	9.14	12.24	25	4.17	8.81
25	13.13	13.13				23	8.81	13.61	26	3.81	3.63
26	9.47	10.59				24	14.10	16.79	27	2.87	4.17
28	16.20	16.20				25	10.97	19.89	29	3.30	3.00
						28	10.59	10.21			
						30	10.59	10.97			

On the mornings of May 24, 25, and 29 the readings obtained at Santa Fe indicate quite steady atmospheric conditions throughout the half-day periods. Reduced to mean solar distance of the earth and extrapolated to zero air mass they give solar radiation intensities of 1.76, 1.79, and 1.77, respectively. Employing the vapor pressures given by Table 2 in applying to the above measurements the Smithsonian "Abridged procedure for determining approximately the value of the solar constant",[1] we obtain 1.89, 1.91, and 1.88, respectively, or values but slightly lower than Abbot's mean value for the solar constant.

Skylight polarization measurements at Washington on six days give a mean of 51 per cent, with a maximum of 58 per cent on May 19.

Table 3 shows that at Washington there was a deficiency in the total radiation received during the month amounting to 3.7 per cent of the normal. At Madison there was an excess amounting to 4.2 per cent. Since the first of the year the deficiency at Washington is 7.9 per cent of the average amount, and at Madison the excess is 0.3 per cent.

TABLE 3.—*Daily totals and departures of solar and sky radiation during May, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.		Excess or deficiency since first of month.	
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Washington.	Madison.
1916.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
May 1	590	237	739	110	−217	110	−217
2	325	547	353	−157	92	− 47	−125
3	531	360	727	46	− 96	− 1	−221
4	394	550	676	− 94	93	− 95	−128
5	534	658	692	44	200	− 51	72
6	622	249	582	130	−210	79	−138
7	231	669	596	−262	210	−183	72
8	544	704	703	50	244	−133	316
9	600	578	559	105	118	− 28	434
10	495	468	716	− 1	8	− 29	442
11	520	762	294	23	301	− 6	743
12	644	385	88	147	− 76	141	667
13	282	244	85	−216	−217	− 75	450
14	169	133	157	−329	−329	−404	121
15	595	668	535	96	206	−308	327
16	228	261	607	−271	−202	−579	125
17	514	634	639	15	170	−564	295
18	460	690	376	− 39	226	−603	521
19	711	538	179	213	73	−390	594
20	658	394	190	160	− 72	−230	522
Decade departure						−201	80

[1] Annals of the Astrophysical Observatory of the Smithsonian Institution, Washington, 1908, 2:115.

TABLE 3.—*Daily totals and departures of solar and sky radiation during May, 1916*—Continued.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.		Excess or deficiency since first of month.	
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Washington.	Madison.
1916.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
May 21	718	162	410	220	−304	− 10	218
22	315	480	676	−183	13	−193	231
23	102	537	678	−396	69	−589	300
24	252	448	609	−245	− 21	−834	279
25	621	419	693	124	− 51	−710	228
26	636	531	626	140	59	−570	287
27	581	458	621	85	− 17	−485	270
28	534	671	570	39	193	−446	463
29	452	242	662	− 42	−239	−488	224
30	267	732	731	−227	249	−715	473
31	637	615	338	144	130	−571	603
Decade departure						−341	81
Excess or deficiency since first of year. gr.-cal.						−4,057	+128
Excess or deficiency since first of year. per cent.						−7.9	+0.3

CIRCUMHORIZONTAL ARC OBSERVED.

By JULIAN T. GRAY, Assistant Observer.

[Dated: Weather Bureau, Cincinnati, Ohio, June 13, 1916.]

On June 5, 1916, while observing a very bright solar halo of the ordinary type, a phenomenon was noticed which at first was believed to be the lower portion of the great halo of 46°. The arc was 30° or more in extent, concave to the sun, and so situated that its middle point appeared vertically beneath the sun. It was also remarkable for its vivid colors, and in this characteristic it bore a strong resemblance to the "circumzenithal arc," an example of which the writer observed at Ludington, Mich., during the winter of 1913–14.

The fact was at once noticed that the arc appeared flat, i. e., not having that degree of curvature which would be expected of a halo of 46°, and it was not concentric with the halo of 22°. So far as we are able to judge, the arc was parallel to the horizon at an altitude of about 20°, with, perhaps, a slight upward curve at either extremity. It therefore seems reasonably evident that we had to do with the "circumhorizontal arc" or "lower tangent arc of the halo of 46°," concerning which Besson says, "So far, only three or four observations of this arc are known."

The phenomenon remained visible for about 15 minutes after discovery—from 12:50 to about 1:05 p. m. (90th Meridian time). During this period the sky was everywhere visibly covered with thin cirrus or cirro-stratus clouds in which numerous white streaks and patches appeared. We endeavored to make such measurements as were possible without instrumental equipment, which, though lacking in that degree of accuracy which would be desirable, are presented with the belief that the possible limits of error in either direction are such that the results obtained may be of some value.

A piece of cardboard in which a pin was stuck perpendicularly at the end of a black line served as a sort of sextant, by means of which our measurements were made. The angles were plotted on the cardboard and measured with a protractor. The measurement was taken in each case from a point as near the middle of the band or ribbon of light as could well be judged.

The radius of the ordinary halo as measured was exactly 22½°, which, considered as a check, may indicate that the other measurements made by the same method

are approximately correct. The solar distance of the arc at 1 p. m. was measured at 46½°, while the altitude of the sun at the same hour two days later was 66°. The sun's altitude at the moment considered must have been between 68° and 63°, where, according to the theory of Bravais, the solar distance of this arc should be between 46° and 47°. (See "Different forms of Halos and their Observation," MONTHLY WEATHER REVIEW, July, 1914.)

THE BLUE OF THE SKY AND AVOGADRO'S CONSTANT.[1]

By D. PACINI.

[*Reprinted from* Science Abstracts, Sect. A, Mar. 25, 1916, §286.]

Rayleigh's theory attributes the blue of the sky to molecular dispersion; but we have also to do with dust and with molecular agglomerations (on ions, on uncharged nuclei produced by the action of ultra-violet light on oxygen, or on water vapor) which are larger in size than the dimensions required by Rayleigh's theory, but which vary in size and number. The author has studied observed departures from the inverse fourth-power law, and tabulated the calculated value of n in λ^{-n}. It is mostly numerically smaller than 4, but has been found as large as 7. The observations are reduced to a series of typical curves, less or more in disaccord with the theoretical curve, and the probable causes of these discrepancies are considered. A perfect atmosphere would give data corresponding to about 62×10^{22} molecules per gram-molecule; the author finds his observations lead to a value of 57×10^{22}. Dember found by analogous methods 28, Abbot and Fowle 52, and King 62.3, $\times10^{22}$. On the whole, this is sufficient to show that the blue of the sky is mainly due to molecular dispersion.—*A. D*[*aniell*].

PHOTOGRAPHY OF ZODIACAL LIGHT AND COUNTERGLOW.[2]

By A. E. DOUGLASS.

[*Reprinted from* Science Abstracts, Sect. A, Apr. 25, 1916, § 424.]

Successful photographs of these phenomena of very slight contrast, were obtained by careful consideration of the conditions to give even illumination and intensification of photographic contrast. A camera lens of very large relative aperture was used (diameter 1 inch, focal length 2 inches), with exposures varying from 8 to 20 minutes. Equally good results were obtained with orthochromatic and ordinary plates, and it was found best to develop with hydroquinone bromide, kept cool, arranged for prolonged development. Evenness of illumination was got by using a special form of panoramic camera, with a focal diaphragm 17 mm. wide, the lens rotating at the rate of 2° per minute. The instrument was provided with three exactly similar lenses rotated by the same clock, so that three negatives were produced for each exposure. For producing positives, these negatives were put together and the copy taken through the combined pictures, thus increasing the contrast values given by a single film.

In the discussion of the paper the question was raised whether it might not be better to make a series of positives from each negative and superpose these for the increase of contrast instead of the negatives; also the importance in such work of attending to the perfect cleanliness of the lens surfaces, elimination of lens or camera glare, danger of diffraction with small apertures, etc.—*C. P. B*[*utler*].

[1] Nuovo cimento, July-Aug., 1915, **10**:131-167.
[2] Phot. jour., Feb. 1916, **56**:44-47; discussion, 47-48.

PROPAGATION OF SOUND IN THE ATMOSPHERE.[3]

By E. VAN EVERDINGEN.

[*Reprinted from* Science Abstracts, Sect. A, Apr. 25, 1916, § 458.]

In various investigations on the propagation over great distances of sounds from intense sources, specially in the case of volcanic eruptions and explosions, deviations have been found, partly regular, partly irregular. The source of sound is always surrounded by an area of regular or irregular shape, where the sound is heard everywhere, but the source is far from being always situated symmetrically within this area, and the dimensions of the latter are not even in the first place determined by the intensity of the sound. In many cases a second area of audibility occurs, separated from the first by a region where no sound at all is heard. Sometimes this second area partly surrounds the first; sometimes it consists only of isolated spots. It can be said generally that the smallest distance from the source of sound for this second area is usually much more than 100 kilometers and that the intensity of sound at this smallest distance is no less than at the outer border of the first area of audibility, which is much nearer to the source of sound. These facts are illustrated by diagrams of seven different cases which have previously been investigated. These are as follows: (1) Explosion of 15,000 kilograms of dynamite at Farde, in Westphalen, December 14, 1903 [G. von der Borne, Abs. 106 (1911)]; (2) explosion of 25,000 kilograms of dynamite near the Jungfrau Railway November 15, 1908 (A. de Quervain); (3) three eruptions of the volcano Asama in Japan on December 7, 1900, December 25, 1910, and April 4, 1911 (F. Fujiwhara); (4) explosion of gunpowder and dynamite at Kobe April 3, 1910 (S. Fujiwhara); (5) explosion of 200,000 kilograms of gunpowder in a magazine at Wiener-Neustadt on June 7, 1912 [J. N. Dörr, Abs. 1295 (1914)].

Two chief lines have been followed in the endeavor to explain these facts. The first way, now quite old, ascribes the abnormal propagation of sound to the influence of variations in temperature and wind velocity in the superposed layers of air in the atmosphere. It is easy to see how, by certain suppositions about the vertical distribution of wind velocity, the peculiarities of the propagation of sound, specially the silent region, may be explained. The influence of temperature, which decreases upward, is a decrease of the velocity of sound in the higher regions, thus causing the sound rays to curve upward from the earth. A horizontal wind in the direction of the sound, and with higher velocities at higher levels, may counteract the above temperature effect and overcome it, so turning the rays down again to the earth. A silent region followed by a second audible area is thus accounted for.

The second and entirely different line of thought was put forward by Von der Borne. He supposes that the appearance of silent regions, in some cases at least, may be due to the change in composition of the atmosphere, which is caused by the unequal decrease of the partial pressures of the constituents of the atmosphere. If no mixing by convection currents occurred, each of the gaseous constituents of the atmosphere would form an atmosphere entirely according to its own laws. In consequence

[3] Proc., K. Acad. Amsterdam, 1916, 6, **18**:933-960.

of this at great heights the denser gases could only occur as a very small percentage and the lighter constituents, of which hydrogen is the most generally known, must gradually begin to predominate. The convection currents alter this state of things only so far as the lower atmosphere (the troposphere) is concerned. Above 10 or 11 kilometers (at least in the Temperate Zone) little convection occurs, and above this level the change of composition is expected to begin. Also above that same level the fall of temperature with height ceases. As the velocity of sound in hydrogen is much greater than that in nitrogen or oxygen, it follows from this that at very great heights the velocity of sound increases so much that the sound rays are curved toward the earth.

In the light of these two competing theories the present author considers the following eight cases which have occurred during the present war: (1) Bombardment of Antwerp, October 7-9, 1914; (2) naval battle on the North Sea, October 17; (3) bombardment of German positions on the Yser by British naval guns, October 18; (4) heavy fighting on the line Ostend-Nieuport-Ypres, October 22; (5) heavy fighting at the Yser Canal, east of Ypres and south of Lille; (6) bombardment of German artillery in Flanders by 12-inch British naval guns, October 28; (7) severe attack of Germans on Ypres, British naval guns in action, heavy fighting at Dixmuiden, on the Lys, and at Messines; (8) naval battle on the North Sea, January 24, 1915. These cases are illustrated by maps and an elaborate table of the meteorological conditions at the times in question. Reviewing these cases, the author notes that the silent region is often displayed, and in the siege of Antwerp in an extraordinarily regular form.

Of the two explanatory theories put forward, the influence of variations of wind and temperature with height leads us to expect an asymmetry with respect to the source of sound and a difference between two mutually perpendicular directions, and permits of all kinds of distances. The physical explanation, on the other hand, requires complete symmetry with respect to the source of sound. It is found that the outer limit of the silent region is only slightly changed by considerable irregularities in the distribution of wind or temperature.

Probably many of the cases observed are explicable on the meteorological theory, although there is not absolute proof of this. In favor of the physical theory it must be noted that the border of the silent region has been always at about 160 kilometers from the probable source of sound and that no appreciable deviations from the circular form have been found.—*E. H. B[arton].*

SPONTANEOUS IONIZATION OF THE AQUEOUS VAPOR OF THE ATMOSPHERE. II.[4]

By G. ODDO.

[*Reprinted from* Science Abstracts, Sect. A, Apr. 25, 1916, §460.]

The author discusses the various views which have been expressed concerning the origin of atmospheric electricity, this being connected largely, if not entirely, with the presence of water vapor. The molecules of the latter, being in a rarified or diluted state, undergo spontaneous ionization in the same way as do electrolytes in dilute aqueous solution; the ionized aqueous vapor of the atmosphere acts, therefore, as a conductor of the second class. In comparison with this source of ions, all other sources, such as the actions of ultra-violet radiation from the sun and of terrestrial radioactive substances, etc., must be regarded as subsidiary.

From the specific humidity of the air, the number of molecules contained in one gram-molecule of a gas, and the number of ions formed from 100 molecules of water at different temperatures, the ionic concentration is calculated for various temperatures and pressures. Fall of temperature diminishes the proportion of water vapor in the air, but starting from 32°C. increases its degree of ionisation. The calculations now made show that the ionic concentration, C_1, is highest and approximately constant between 5° and 20°; it remains high even at −10°C., but diminishes rapidly between −10° and −20°, in spite of the rapid increase in the degree of ionization; it is also high at 25°, decreasing rapidly at higher temperatures and becoming virtually zero at 32°. With varying pressure the ionic concentration changes nearly in accordance with Boyle's law, $p \times C_1 = K$. It will be seen that the ionic concentration of the atmosphere is at its maximum for those conditions of temperature which are most suitable to animal and vegetable life, and it may be assumed that the latter constitutes a true indicator of this ionic concentration.

At 15° and a pressure of 760 millimeters, 1 kilogram of moist air, occupying 773.4 liters at 0° and 760 millimeters in the dry state, contains 89×10^{-20} hydrogen and hydroxyl ions, and such marked ionization would lead to the supposition that many processes of oxidation and reduction, occurring in contact with air, are electrolytic in character. A number of natural processes of the inorganic, vegetable, and animal kingdom are discussed on these lines.—*T. H. P[ope.]*

VARIATION OF EMANATION CONTENT OF SPRINGS.[5]

By R. R. RAMSEY.

[*Reprinted from* Science Abstracts, Sect. A, Apr. 25, 1916, §451.]

An examination of the variation of the emanation content of certain springs shows roughly that an increase coincides with a season of rain and a decrease with dry weather.—*A. B. W[ood.]*

PLANETARY PHENOMENA AND SOLAR ACTIVITY.[6]

By T. KÖHL.

[*Reprinted from* Science Abstracts, Sect. A, Mar. 25, 1916, §297.]

Jupiter's northern cloud belts appear to be specially weak at times of sun-spot maxima and become broader and more conspicuous during minima. The secondary light on the dark side of Venus is mentioned in relation to the occurrence of auroral displays on the earth.—*C. P. B[utler.]*

FREE-AIR DATA BY MEANS OF SOUNDING BALLOONS, FORT OMAHA, NEBR., JULY, 1914.

WILLIAM R. BLAIR, Professor of Meteorology in charge.

[Dated: Aerological Investigations, Weather Bureau, Washington, Mar. 10, 1916.]

The primary purpose of this series of observations was the study of the diurnal variation of the different meteorological elements observed at the higher levels. Our observation of this variation[1] had heretofore been by

[4] Gazz., Soc. chim. Ital., 1915, 1, 45: 395-412.

[5] Proc., Indiana acad. sci., 1914, p. 489.

[6] Astron. Nachr. No. 4821. *Abstracted* in Nature, Jan. 6, 1916, 96: 521.

[1] The diurnal system of convection, Bulletin of the Mount Weather Observatory, 1914, 6, part 5, pp. 221-252.

means of kites and was consequently limited to levels up to 3 kilometers. As shown in Table 1, three ascensions, those of July 1 at midnight, July 9 and 11 at midday, were for the purpose of carrying up self-recording pyrheliometers belonging to the Smithsonian Institution. No meteorograph was carried in these ascensions. Meteorographs were taken up in later ascensions on the 9th and 11th. temperature of the air in which it was to record. No corrections to its indications on account of temperature were necessary. In this series of ascensions the balloons were followed with two theodolites, the distance between the theodolites being 5,088 meters. The direction of this base line is south 9.9° east. A comparison of the heights determined by the two methods, Table 2, indi-

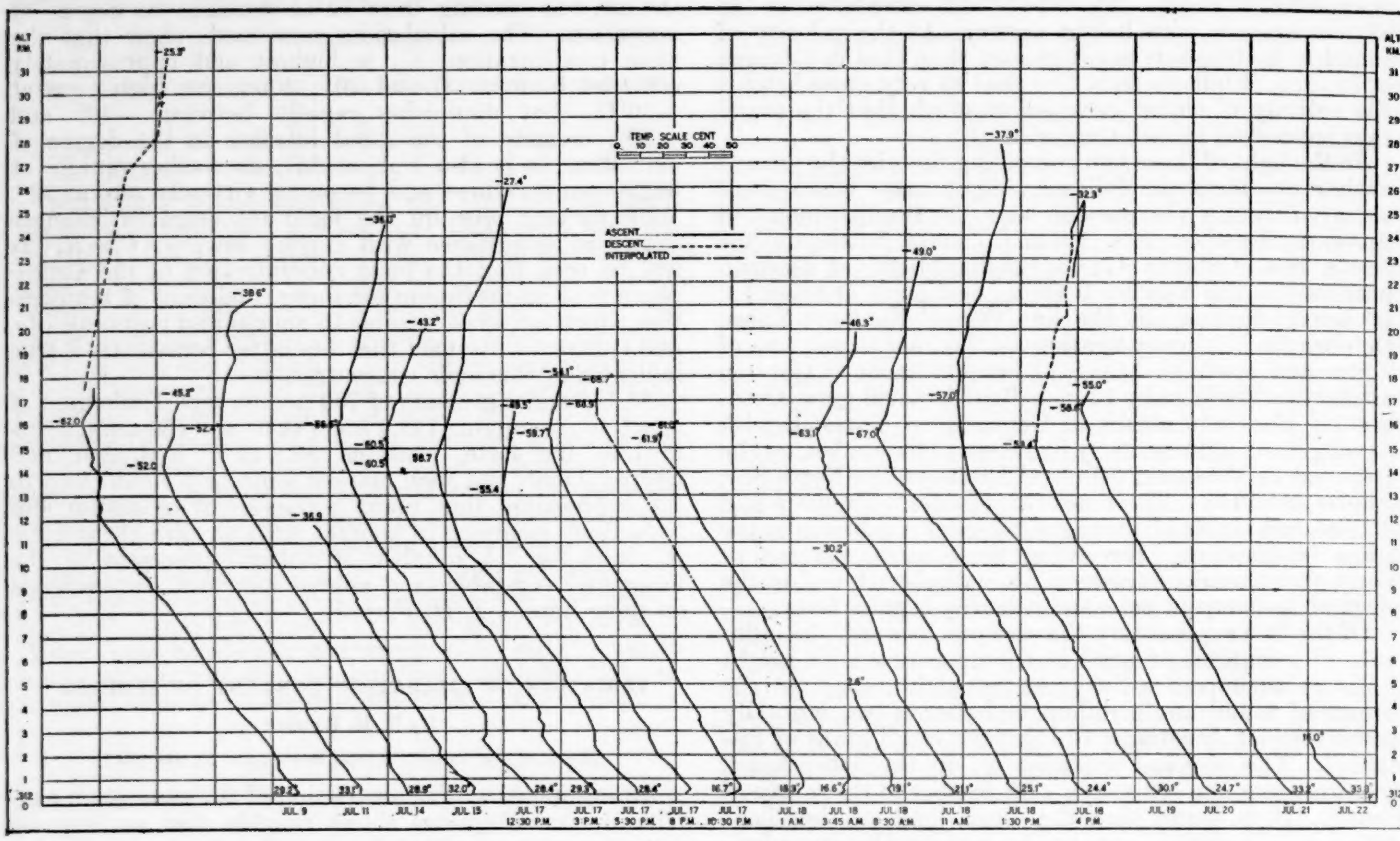

FIG. 1.—Vertical temperature gradients at Fort Omaha, Nebr., July 9 to 22, 1914.

The series of ascensions made during the 17th and 18th, in which balloons were sent up every two and one-half hours, was preceded, also followed, by several daily ascensions. The balloon sent up at 6:05 a. m., July 18, was not found. In the ascensions of July 16 and at 8:30 a. m., July 18, only partial records were obtained because the clocks stopped.

The balloons used in this series were similar in material and construction to those used since 1910 at Huron, S. Dak., Fort Omaha, Nebr., and Avalon, Cal. Their ascensional rates show a variation with altitude similar to that shown in the previous series of ascensions when the balloons were sent up during insolation. In those ascensions made at night, when the sun was not shining on the balloons, the ascensional rate is quite uniform. This fact supports the explanation [2] of the variable ascensional rate when the sun shines on the balloon.

The instruments used and the method of calibrating them are the same as have been used in previous series of soundings.[2]

In all free-balloon soundings made by the Weather Bureau prior to the series under discussion the altitudes were computed from the indications of the barometer. The barometer was calibrated at approximately the

cates a small difference in the mean values. Heights by triangulation are somewhat higher than those by the barometer. If the second ascension made on July 17 were not included in Table 2, practically no difference in the two methods of determining heights would be shown. In the consideration of the pressure-altitude relation it seemed desirable to have altitudes determined independently; also, to have a comparison of triangulated and barometric altitudes.

The data obtained in each ascension are shown in Table 3. The temperature-altitude relation found in each observation is graphically presented in figure 1. The mean value of this relation is shown in figure 2. Free-air isotherms for the period July 14 to 21 are shown in figure 3. In this diagram, which is intended to give a general view of the temperature changes for the period, only one each of the ascensions made on July 17 and on July 18 have been used. The minimum temperature at the base of the upper inversion is found at altitudes ranging from 14.2 km. to 17.1 km. Below these levels the gradient is fairly uniform, except for slight interruptions at levels in which condensation or evaporation of moisture is in progress. A surface inversion of temperature is fairly well defined in ascensions made between the evening of July 17 and the morning of the 18th. Because of the clear weather conditions prevailing on the evening of

[2] Bulletin of the Mount Weather Observatory, 1911, 4:186. MONTHLY WEATHER REVIEW, 1914, 42:410, 411.

the 17th, the earth's surface cooled rather rapidly by radiation. The air resting on the surface became cool by contact with it. The inversion of temperature continues to begin at the earth's surface until about sunrise. After this the earth's surface becomes warmer by the absorption of the sun's heat. The air next the surface is heated by contact. Convection sets in and the heat is gradually carried to higher and higher levels. On a clear day the inversion would disappear a few hours after sunrise, but the morning of the 18th became cloudy a few hours after sunrise. The earth's surface did not, therefore, become very warm, nor was convection very active. Consequently the inversion persisted well into the afternoon, beginning at slightly higher levels as the upper limit of the local convective mixing increased in altitude.

The curve shown in figure 2 has the same general characteristics as have the similar curves shown in MONTHLY WEATHER REVIEW, 1914, **42:** 413, figure 5, and Bulletin of the Mount Weather Observatory, 1911, **4:** 302, figure 31. In each of these three mean curves there is but one observation at the very high levels—i. e., at 30 kilometers above sea and a few levels below. These three high ascensions were all made in the summer half of the year, their dates being September 1, 1910, July 30, 1913, and July 9, 1914. The shape of the extreme upper part of the curve—say from 25 to 30 kilometers—should, therefore, be thought of as belonging to the summer season.

In figures 4 and 5 are plotted the horizontal projections of the paths taken by the balloons in the various ascensions. Figure 5 has plots for all ascensions made in the series of July 17 and 18. Figure 4 contains the plots for all other ascensions made in July, 1914. The variable winds indicated in the lower levels by these plots are related fairly well to the surface pressure distribution shown in figure 6. Above the 5 or 6 kilometer level a steady westerly wind seems to prevail up to about the 15 or 16 kilometer level. Here the wind direction begins to change, and by the time the 20-kilometer level has been reached it has become decidedly easterly. The highest rate of air movement from a westerly direction is found at about the 11 to 15 kilometer levels, or about 2 or 3 kilometers below the level of minimum temperature. The level of minimum temperature is found in and usually near the top of the westerly current. The rate of air movement from an easterly direction is found to be increasing with altitude as far up as our observations extend. A rate of 19 m.p.s. at about the 31-kilometer level has been observed.

The observations of humidity for the period have been expressed in grams per cubic meter in Table 4. It may be noted here, as in data obtained in previous series, that the minimum moisture content of the air is found at the levels of minimum temperature. If the ratio of the weight of water vapor to the weight of dry air at the different levels be considered, its value in the average for the observations recorded in Table 4 is approximately 1¼ per cent at the surface, 0.6 per cent at the 31-kilometer level, but only 0.002 per cent at the 16-kilometer level. These observations seem to indicate that the air of the upper westerly current is drier than that of the easterly current next above it.

The data obtained in the 12 ascensions made at intervals of two and one-half hours from 12:30 p. m., July 17, to 4:00 p. m., July 18, are the beginning of a number of such series of data having for its purpose the study of

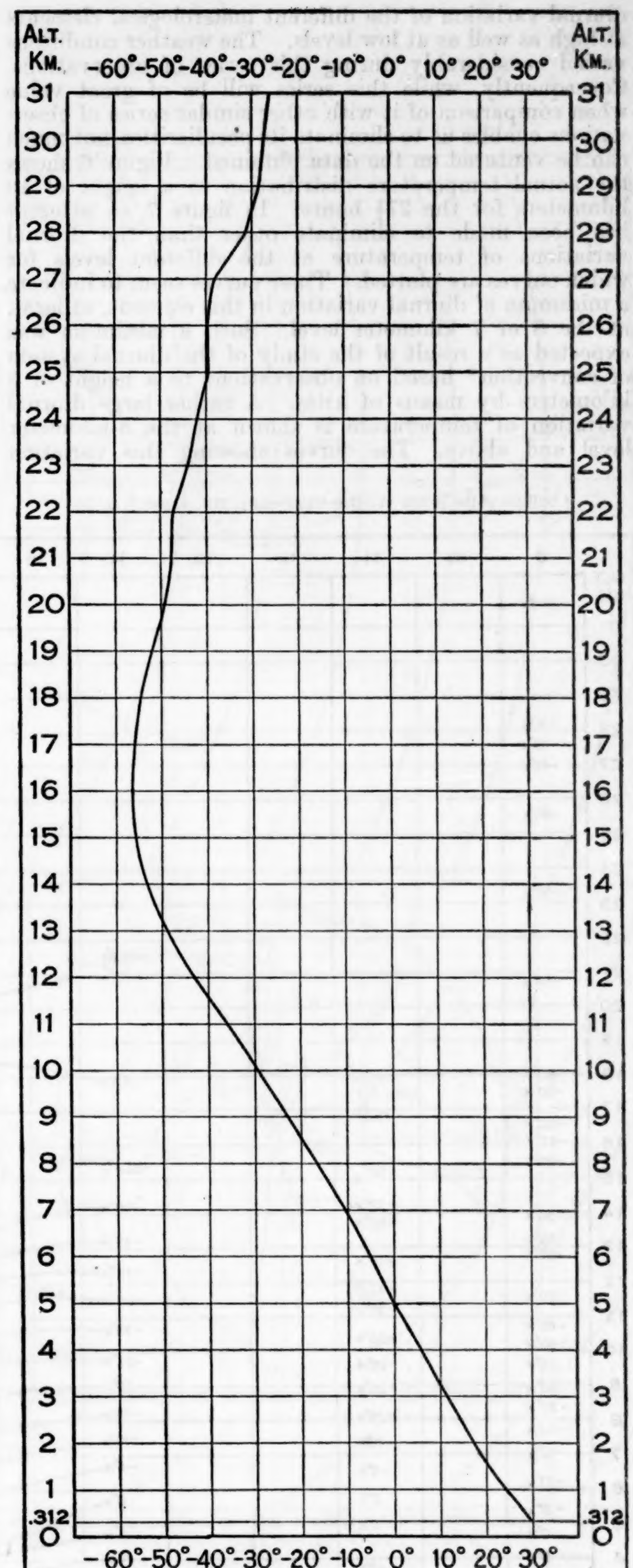

FIG. 2.—Mean vertical temperature gradient at Fort Omaha, Nebr., July 9 to 22, 1914.

diurnal variation of the different meterological elements at high as well as at low levels. The weather conditions varied considerably during this series of observations. Consequently, while this series will be of great value when comparison of it with other similar series of observations enables us to eliminate its peculiarities, not much can be ventured on the data obtained. Figure 6 shows the actual temperature distribution to a height of 10 kilometers for the 27½ hours. In figure 7 an attempt has been made to eliminate other than the diurnal variations of temperature at the different levels for which curves are plotted. These curves seem to indicate a minimum of diurnal variation in this element, at least, at the 6 or 7 kilometer level. Such a minimum was expected as a result of the study of the diurnal system of convection [3] based on observations to a height of 3 kilometers by means of kites. A rather large diurnal variation of temperature is shown at the 8-kilometer level and above. The curves showing this variation differ from those below in that the maximum temperature is found between 10 and 11 a. m. and the minimum at from 8 to 9:30 p. m. This maximum and minimum occur earlier than one would expect them if they were mainly accounted for by the absorption by the air at these levels of direct and reflected solar radiation. It seems likely that the peculiar distribution of moisture found in the period of observation up to the 12-kilometer level is, in part at least, responsible for the peculiarities noted above in the temperature curves.

Table 5 shows the distribution of absolute humidity at different levels throughout the 27½-hour period. The gradual increase from the values observed at 12:30 p. m., July 17, to approximately twice these values at 4 p. m., July 18, obtain up to the 12-kilometer level only.

The balloons sent up at night carried a small electric light. By this means they could be followed with the theodolite to a limited distance, and the wind direction and velocity at these hours obtained. Table 6 shows the hourly wind direction and velocity at levels up to 6 kilometers above sea.

[3] Bulletin of the Mount Weather Observatory, 1913, 6, part 5, p. 230.

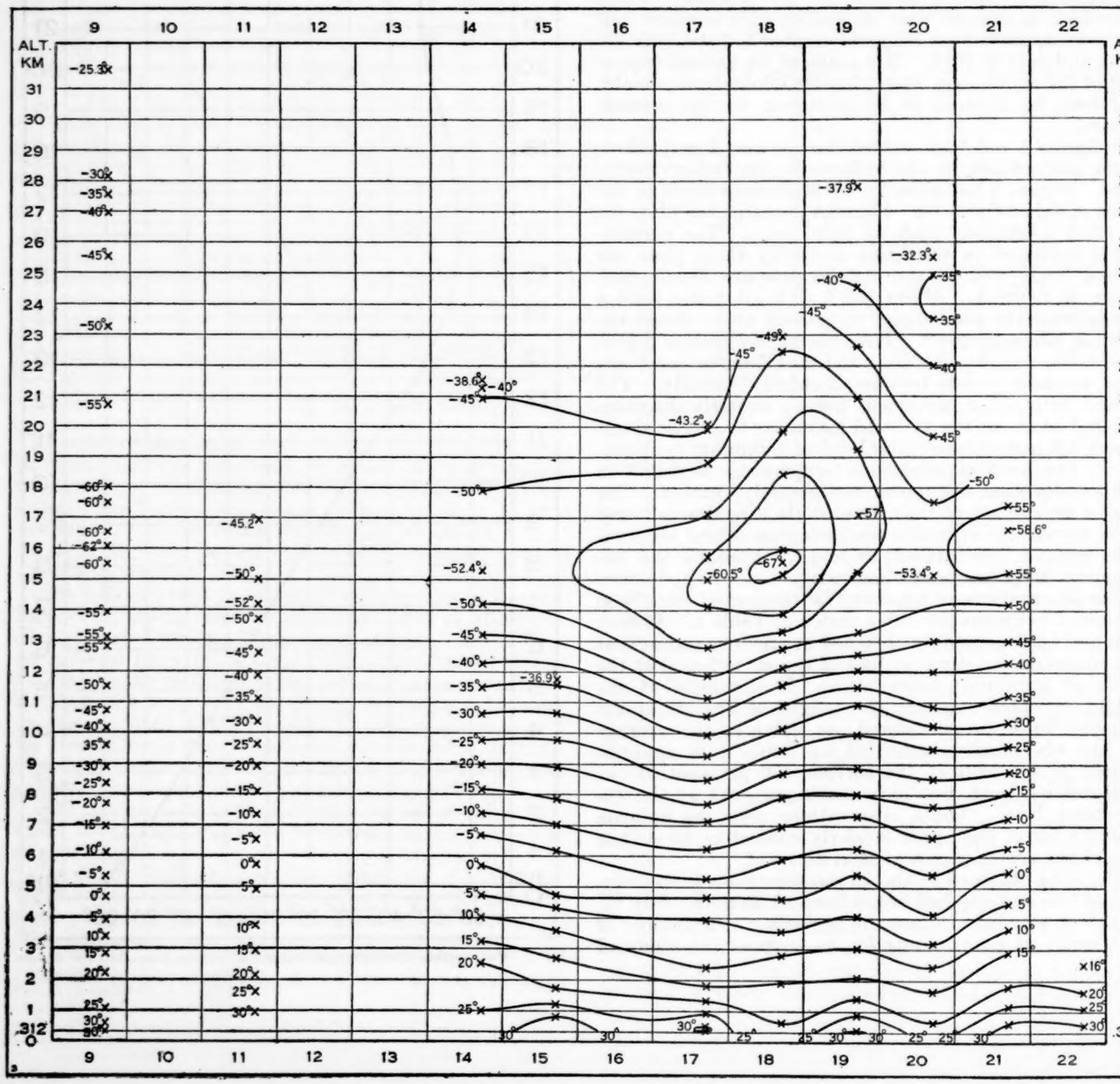

FIG. 3.—Free-air temperatures at Fort Omaha, Nebr., July 9 to 22, 1914.

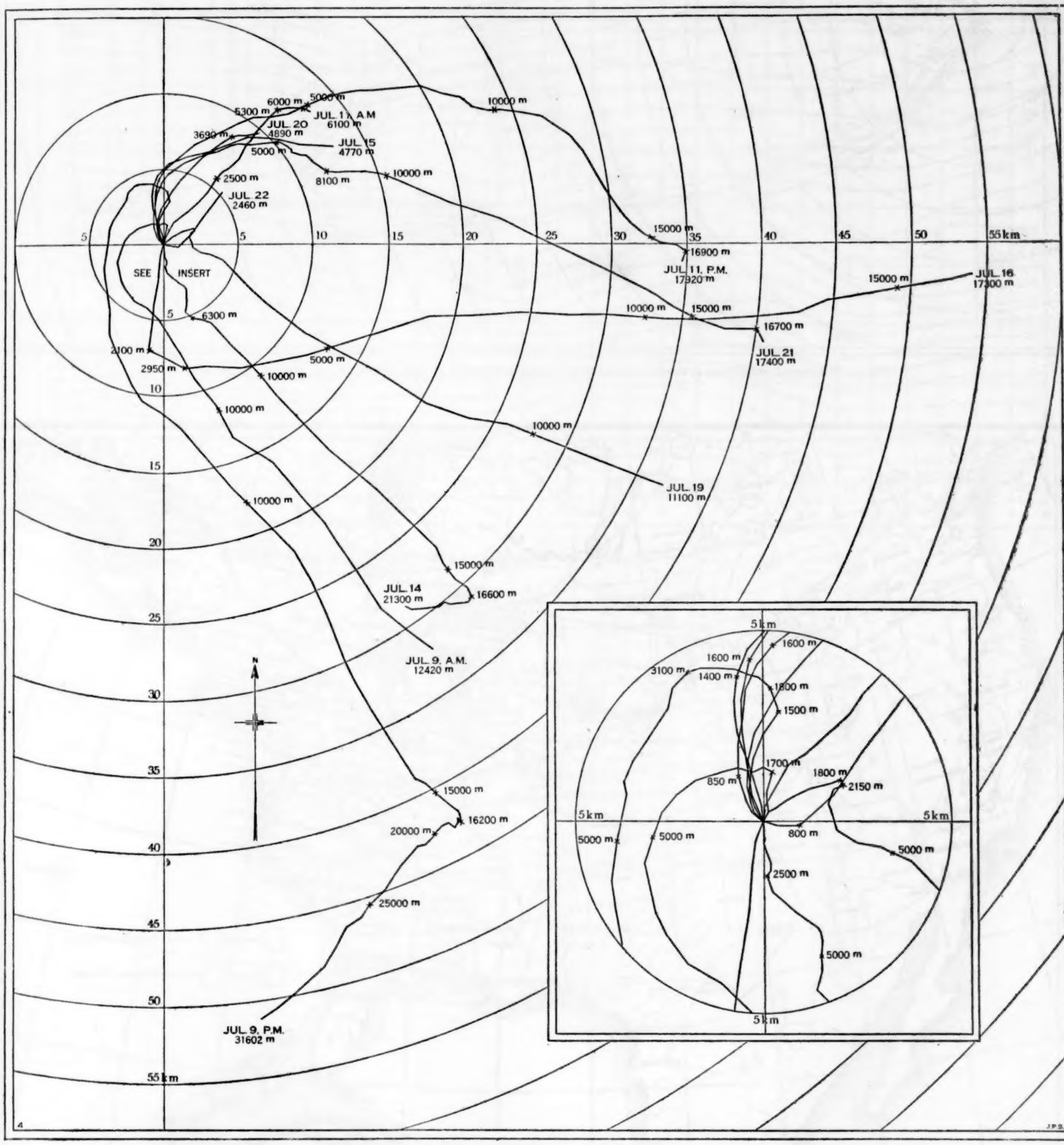

FIG. 4.—Horizontal projections of the paths of sounding balloons liberated at Fort Omaha., Nebr., July 9 to 16, and 19 to 22, inclusive, 1914.

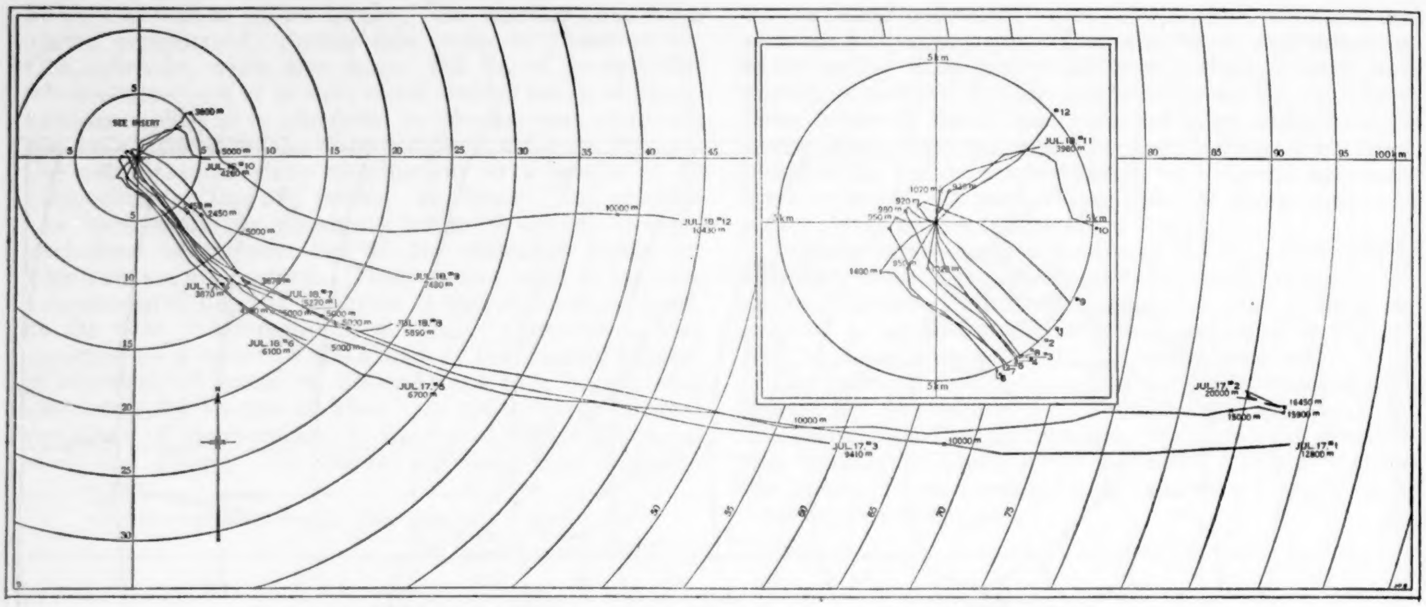

FIG. 5.—Horizontal projections of the paths of sounding balloons liberated at Fort Omaha, Nebr., July 17 and 18, 1914.

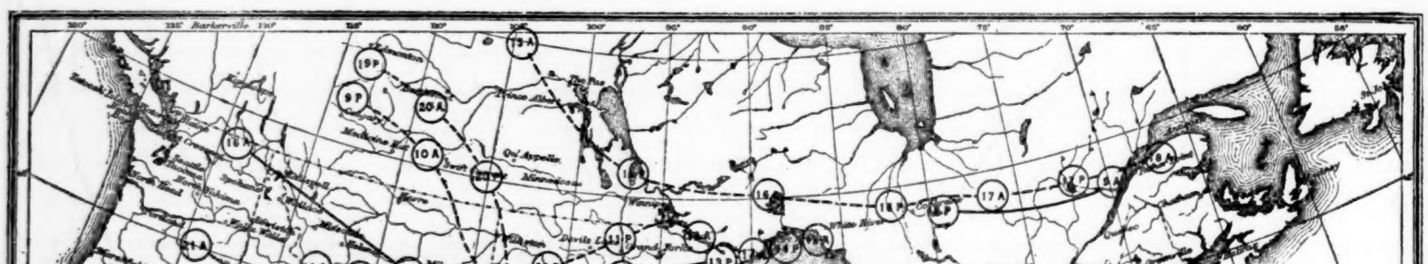

FIG. 6.—Tracks of HIGHS and LOWS across the central United States, July 9 to 22, 1914.

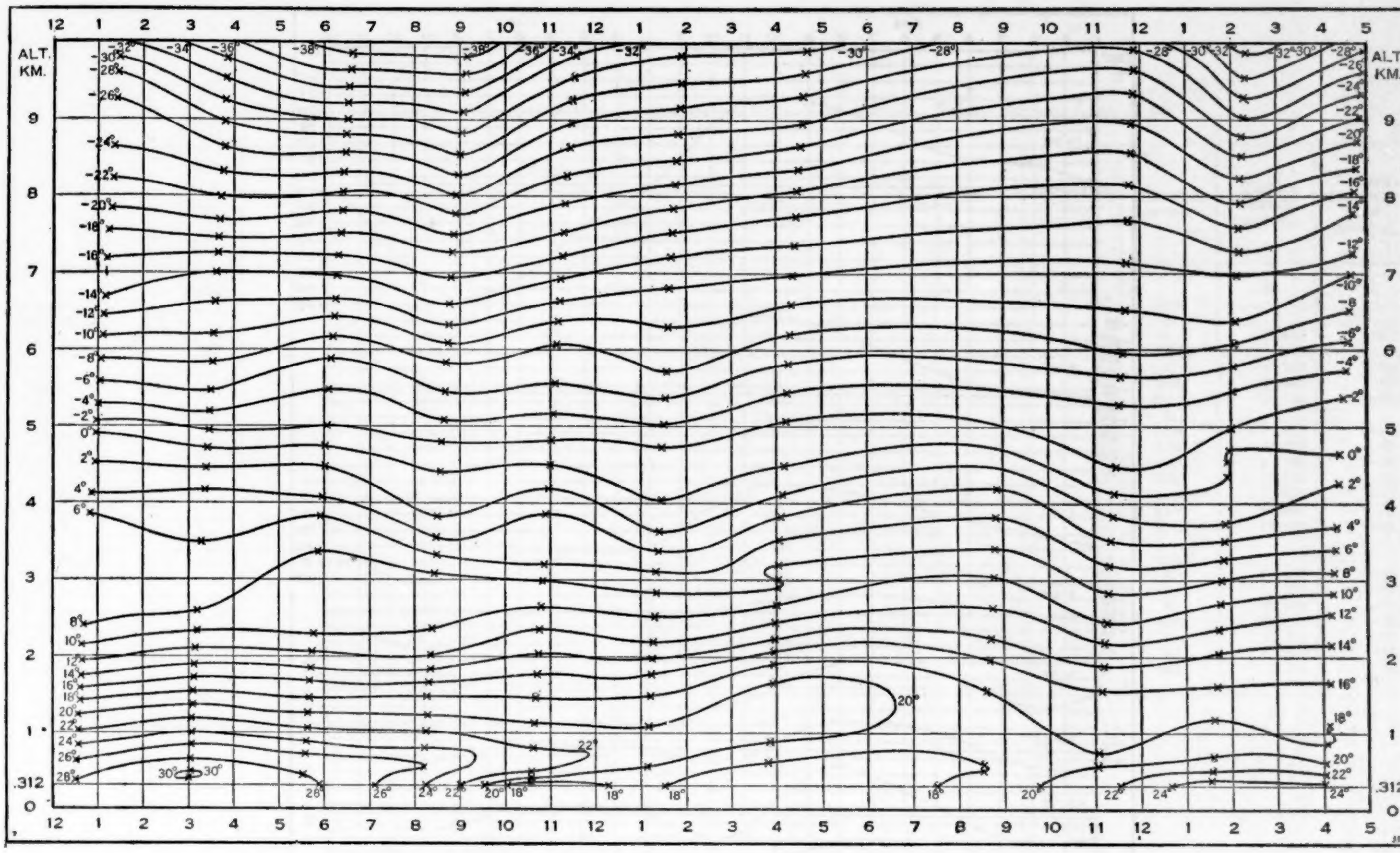

FIG. 7.—Free-air temperatures at Fort Omaha, Nebr., 12:30 p. m. July 17 to 4 p. m. July 18, 1914.

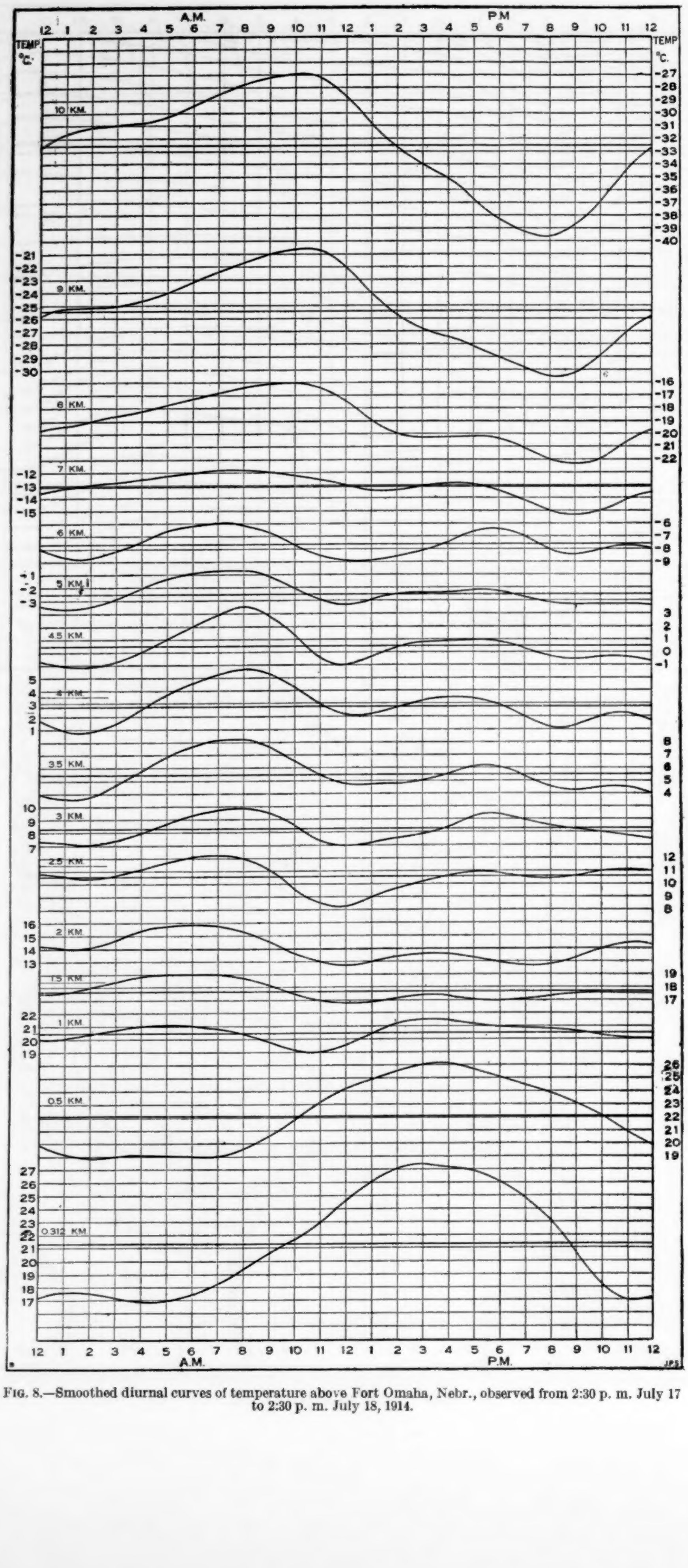

FIG. 8.—Smoothed diurnal curves of temperature above Fort Omaha, Nebr., observed from 2:30 p. m. July 17 to 2:30 p. m. July 18, 1914.

TABLE 1.—*Statistics of sounding balloon ascensions from Fort Omaha, Nebr., during July, 1914.*

Date.	Hour C. S. T.	Balloons. Number.	Balloons. Ascensional force.	Landing point (nearest town).	Horizontal distance traveled.	Direction traveled.	Highest altitude reached.	Lowest temperature recorded.
1914.			*Kg.*		*Km.*		*M.*	*°C.*
July 1*	11:26 p.	3		Harvard, Iowa	235	ESE.		
July 9*	10:11 a.	3	1.1	Omaha, Nebr	6	S.		
July 9	4:15 p.	1	0.4	Murray, Nebr	55	S.	**31,602**	−62.0
July 11*	10:30 a.	3	0.8	Carson, Iowa	41	E.		
July 11	4:02 p.	1	0.6	Oakland, Iowa	43	E.	17,920	−52.0
July 14	4:04 p.	1	0.6	Tabor, Iowa	53	SSE.	21,358	−52.4
July 15	4:02 p.	1	0.6	Brayton, Iowa	89	ENE.	11,748	−36.9
July 16	4:00 p.	1	0.8	Atlantic, Iowa	80	E.		
July 17	12:30 p.	1	0.8	Cromwell, Iowa	128	ESE.	24,500	−56.6
July 17	3:00 p.	1	0.6	Carl, Iowa	115	ESE.	20,080	−60.5
July 17	5:31 p.	1	0.8	Arispe, Iowa	150	ESE.	25,953	−58.7
July 17	8:10 p.	2	1.0	Canton, Mo	388	ESE.	16,570	−55.4
July 17	10:34 p.	2	1.0	Leon, Iowa	192	ESE.	17,837	−59.7
July 18	1:07 a.	2	1.1	Kingston, Iowa	181	ESE.	17,560	−68.9
July 18	3:47 a.	2	1.0	Grand River, Iowa	180	ESE.	16,169	−61.9
July 18	6:05 a.	1	0.8					
July 18	8:30 a.	1	0.7	Williamson, Iowa	118	ESE.		
July 18	11:00 a.	1	0.8	Oakland, Iowa	48	E.	10,411	−30.2
July 18	1:32 p.	1	0.8	Spaulding, Iowa	139	E.	19,903	−63.1
July 18	4:00 p.	1	0.8	Orient, Iowa	128	E.	22,930	−67.0
July 19	4:03 p.	1	0.8	Stanton, Iowa	87	ESE.	27,782	−57.0
July 20	4:01 p.	1	0.8	Griswold, Iowa	71	E.	25,481	−53.4
July 21	4:00 p.	1	0.8	Griswold, Iowa	66	E.	17,402	−58.6
July 22	4:00 p.	2	1.1	Crescent, Iowa	13	NE.	2,464	16.0

*These three ascensions were made for the Smithsonian Institution; no meteorograph was used.

TABLE 2.—*Comparison of altitude determinations from pressure and triangulation.*

Date.	Altitudes, meters, from pressure.																					
	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000
	Altitudes from triangulation.																					
1914.	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*	*M.*
July 9	500	1,000	1,500	2,000	2,500	2,920	3,450	4,040	4,550	5,030	6,080	7,080	8,000	8,960	9,910	10,880	11,910	12,970	14,000	15,000	16,000	17,000
July 11	500	1,000	1,500	2,000	2,500	3,000	3,580	4,120	4,650	5,150	6,150	7,150	8,160	9,260	10,400	11,430	12,430	13,420	14,380	15,370	16,360	17,400
July 14	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000	13,000	13,870			
July 15	470	930	1,430	2,000	2,580	3,050	3,570	4,170	4,620													
July 17, 1.	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000											
July 17, 2.	500	1,000	1,600	2,140	2,670	3,240	3,760	4,330	4,860	5,370	6,380	7,430	8,420	9,460	10,500	11,500	12,560	13,620				
July 17, 3.	500	1,080	1,630	2,200	2,720	3,250	3,760	4,300	4,810	5,400	6,530											
July 18, 9.	500	1,000	1,500	2,000	2,500	3,050	3,560	4,070	4,580													
July 18, 10.	500	1,000	1,500	2,000	2,470	2,960	3,430	3,960														
July 18, 11.	580	1,150	1,630	2,120	2,620	3,180	3,720															
July 18, 12.	500	970	1,450	1,970	2,480	3,000	3,460	3,910	4,400	4,890	5,830	6,850	7,870	9,080	10,360							
July 19	500	1,000	1,360	1,800	2,320	2,900	3,500	4,000	4,500	5,000												
July 20	530	1,100	1,500	2,050	2,600	3,170	3,700															
July 21	500	1,000	1,500	2,000	2,500	3,000	3,500	3,960	4,420	4,900	5,900	6,920	7,900	8,870	9,800	10,720	11,600	12,500	13,420	14,470	15,450	
Means	**510**	**1,020**	**1,510**	**2,020**	**2,530**	**3,040**	**3,570**	**4,070**	**4,580**	**5,080**	**6,110**	**7,070**	**8,060**	**9,100**	**10,160**	**11,110**	**12,100**	**13,100**	**13,920**	**14,950**	**15,940**	**17,200**
Mean differences, %	2	2	1	1	1	1	2	2	2	2	2	1	1	1	2	1	1	1	1	0	0	1

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*

JULY 9, 1914.

Time.	Altitude.	Pressure.	Temperature.	$\triangle t$ 100 m.	Humidity.		Wind.		Remarks.
					Relative.	Absolute.	Direction.	Velocity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
A. M.									
10 11.0	312	736.6	27.2		70	18.038	S. 20° W.	1.0	No meteorograph.
10 12.2	500						S. 7° W.	2.2	1/10 Ci., w.
10 15.1	1,000						S. 14° W.	3.3	Light haze.
10 18.0	1,500						S. 10° W.	2.0	
10 20.8	2,000						N. 84° E.	3.1	
10 23.6	2,500						E.	3.6	
10 26.3	3,000						N. 84° E.	5.0	
10 29.0	3,500						N. 51° E.	5.2	
10 31.6	4,000						N. 34° E.	4.6	
10 34.1	4,500						N. 20° E.	6.2	
10 36.5	5,000						N. 18° E.	6.7	
10 41.1	6,000						N. 27°W.	5.4	
10 45.3	7,000						N. 59°W.	8.1	
10 49.2	8,000						N. 30°W.	9.4	
10 52.7	9,000						N. 30°W.	16.9	
10 56.2	10,000						N. 32°W.	19.4	3/10 Ci., w.
P. M.									
4 15.0	312	735.3	29.2		52	14.955	S. 38° E.	4.2	Few Ci.St., nw,
4 15.6	356	731.7	31.9	−6.14	45	14.971	S. 38° E.	4.2	on eastern hori-
4 17.1	500		30.7		41	12.790	S. 20° E.	6.3	zon.
4 18.4	650	707.9	29.4	0.85	37	10.757	S. 4° E.	5.7	
4 20.8	1,000		25.8		43	10.251	S. 12° W.	5.6	
4 21.3	1,089	673.4	24.9	1.03	44	9.973	S. 17° W.	5.7	
4 24.2	1,422	648.1	22.6	0.69	55	10.940	S. 17° W.	6.0	
4 25.0	1,500		22.6		48	9.547	S. 1° E.	5.1	
4 27.4	1,789	621.0	22.6	0.00	20	3.978	S. 23° E.	3.0	Cloudless.
4 29.4	2,000		21.3		18	3.323	S. 59° E.	3.5	
4 33.0	2,408	578.1	18.7	0.63	15	2.379	S. 65° E.	3.0	
4 34.0	2,500		17.9		18	2.723	S. 76° E.	3.6	
4 38.6	3,001	539.0	13.6	0.86	21	2.451	N. 76° E.	2.9	
4 43.0	3,500		8.8		28	2.421	N. 21° E.	5.2	
4 44.5	3,763	491.6	6.2	0.97	32	2.340	N. 29° E.	7.5	
4 46.7	4,000		4.3		32	2.066	N. 33° E.	5.8	
4 49.8	4,430	453.4	0.9	0.79	33	1.697	N. 18° E.	5.8	
4 50.3	4,500		0.6		33	1.662	N. 13° E.	6.2	
4 52.1	4,703	438.0	− 0.2	0.40	33	1.570	N. 9° E.	6.8	
4 53.9	5,000		− 2.5		32	1.270	N. 9° E.	6.8	
4 56.3	5,282	407.1	− 4.6	0.76	32	1.073	N.	7.4	
5 00.8	6,000		− 9.3		30	0.685	N. 8° W.	9.1	
5 02.0	6,177	363.3	−10.4	0.65	29	0.604	N. 4° W.	11.0	
5 07.2	7,000		−15.1		27	0.373	N.26° W.	10.0	
5 07.5	7,030	324.9	−15.3	0.57	27	0.367	N.25° W.	9.9	
5 11.5	7,763	295.1	−20.6	0.72	27	0.227	N.40°W.	10.6	
5 13.0	8,000		−22.4		27	0.191	N.59° W.	11.2	
5 15.3	8,455	268.7	−25.8	0.75	26	0.134	N.50°W.	13.9	
5 18.4	9,000		−30.9		27	0.085	N.38° W.	14.9	
5 19.0	9,103	245.7	−31.9	0.94	27	0.076	N.37° W.	15.2	
5 20.3	9,383	235.9	−32.8	0.32	27	0.070	N.41° W.	15.5	
5 23.5	10,000		−38.7		26	0.036	N.47° W.	15.0	
5 23.6	10,050	214.9	−39.2	0.96	26	0.034	N.47° W.	15.1	
5 26.9	10,776	193.7	−45.4	0.85	26	0.017	N.45° W.	18.5	
5 28.1	11,000		−46.4		25	0.015	N.37° W.	19.4	
5 28.9	11,190	182.2	−47.3	0.46	24	0.013	N.31° W.	20.0	
5 32.0	11,933	162.9	−53.2	0.79	24	0.006	N.22° W.	19.0	
5 32.7	12,000		−53.5		24	0.006	N.21° W.	19.6	
5 33.3	12,214	156.3	−54.5	0.46	24	0.005	N.21° W.	19.6	
5 34.3	12,475	150.1	−53.8	−0.27	24	0.006	N.23° W.	19.1	
5 36.4	12,916	140.5	−55.3	0.34	24	0.005	N.29° W.	20.4	
5 37.1	13,000		−55.2		24	0.005	N.30° W.	18.6	
5 40.3	13,800	122.8	−53.8	−0.17	24	0.006	N.32° W.	17.2	
5 41.2	14,000		−55.5		24	0.005	N.39° W.	16.1	
5 43.1	14,324	113.2	−58.2	0.84	24	0.003	N.59° W.	13.5	
5 44.0	14,612	108.5	−57.2	−0.35	22	0.004	N.58° W.	12.6	
5 45.4	15,000		−58.5		22	0.003	N.48°W.	11.9	
5 49.0	16,000		−61.8		22	0.002	N.13° W.	5.8	
5 49.3	16,085	86.1	−62.0	0.33	22	0.002	N.10° E.	5.4	
5 50.6	16,329	83.1	−61.4	−0.25	22	0.002	S. 58° E.	3.6	
5 52.4	17,003	74.9	−57.2	−0.62	24	0.004	N.34° E.	2.3	
5 55.5	17,562	68.5	−57.1	−0.02	22	0.004	N.52° E.	4.1	Clock stopped un-
5 57.0	18,000						S. 58° E.	4.2	til 6:31 p. m.
6 00.6	19,000						N.50° E.	3.2	
6 04.2	20,000						N.23° E.	2.1	
6 07.3	21,000						N. 55°E.	6.3	
6 10.2	22,000						N.57°E.	7.0	
6 13.0	23,000						N.37°E.	8.3	
6 15.7	24,000						N.38°E.	12.5	
6 18.0	25,000						N.42°E.	10.3	
6 20.3	26,000						N.51°E.	9.1	
6 22.5	27,000						N.35°E.	11.7	
6 24.5	28,000						N.30°E.	12.3	
6 26.4	29,000						N.43°E.	17.7	
6 28.2	30,000						N.50°E.	16.9	
6 30.0	31,000						N.54°E.	18.9	
6 31.0	31,602	8.6	−25.3	−0.11	23	0.124			Balloon burst.
6 31.3	31,000		−26.0		23	0.116			
6 31.8	30,000		−27.1		23	0.104			
6 32.3	29,000		−28.2		23	0.093			
6 32.7	28,252	13.7	−29.0	−0.86	23	0.086			
6 32.8	28,000		−31.2		23	0.070			
6 33.5	27,000		−39.8		23	0.028			
6 33.7	26,690	17.1	−42.5	−0.21	23	0.021			
6 34.0	26,000		−43.9		23	0.018			
6 34.5	25,000		−46.0		22	0.013			
6 35.0	24,000		−48.1		21	0.010			

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 9, 1914—Continued.

Time.	Altitude.	Pressure.	Temperature.	$\triangle t$ 100 m.	Humidity.		Wind.		Remarks.
					Relative.	Absolute.	Direction.	Velocity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
6 35.5	23,000		−50.2		20	0.008			
6 35.9	22,000		−52.3		19	0.006			
6 36.0	21,881	35.2	−52.8	−0.19	19	0.005			
6 36.6	21,000		−54.5		19	0.004			
6 37.3	20,000		−56.4		19	0.003			
6 38.0	19,000		−58.3		19	0.002			
6 38.7	18,000		−60.2		19	0.002			
6 39.0	17,606	67.9	−60.8		19	0.002			

JULY 11, 1914.

Time.	Altitude.	Pressure.	Temperature.	$\triangle t$ 100 m.	Relative.	Absolute.	Direction.	Velocity.	Remarks.
A. M.									
10 30.3	312						S. 11° W.	5.5	No meteorograph.
10 31.2	500						S. 11° W.	5.5	Few Ci., w.
10 33.0	1,000						S. 30° W.	8.9	
10 35.6	1,500						S. 52° W.	8.8	
10 39.0	2,000						S. 40° W.	8.2	
10 42.4	2,500						S. 38° W.	6.1	
10 46.0	3,000						S. 54° W.	7.7	
10 49.2	3,500						S. 27° W.	5.4	
10 52.3	4,000						S. 38° W.	6.8	
10 55.2	4,500						S. 41° W.	5.5	
10 58.3	5,000						S. 44° W.	5.9	
11 03.8	6,000						N. 72° W.	8.3	
P. M.									
4 02.0	312	732.0	33.1		57	20.212	S. 23° E.	4.2	5/10 Cu., sw.
4 03.5	500		33.2		46	16.398	S. 20° E.	6.0	Few Ci., w.
4 04.4	631	706.4	33.3	−0.06	39	13.976	S. 13° E.	7.6	
4 07.3	958	681.0	29.8	1.07	45	13.371	S. 6° E.	6.4	
4 07,5	1,000		29.5		45	13.155	S. 5° E.	6.5	
4 11.0	1,503	640.1	26.0	0.70	48	11.572	S. 12° W.	9.0	
4 14.8	2,000		21.7		43	8.123	S. 52° W.	8.7	
4 18.2	*2,493		17.5	0.86	38	5.613	S. 58° W.	9.5	
4 21.6	3,000		14.0		33	3.858	S. 66° W.	9.0	
4 24.8	3,500		10.6		28	2.713	S. 65° W.	9.5	
4 25.3	*3,600		9.9	0.69	27	2.503	S. 70° W.	9.5	
4 27.7	4,000		9.4		22	1.976	S. 86° W.	9.4	
4 28.8	*4,200		9.1	0.13	20	1.763	S. 84° W.	10.1	
4 30.5	4,500		7.0		17	1.310	S. 69° W.	7.6	
4 32.2	4,825	431.5	4.8	0.69	14	0.934	S. 67° W.	7.6	
4 33.0	5,000		3.8		13	0.812	S. 68° W.	8.2	
4 37.6	6,000		− 2.1		10	0.410	S. 78° W.	8.2	
4 41.8	7,000		− 8.0		8	0.203	S. 85° W.	12.4	
4 44.1	7,592	309.9	−11.5	0.59	6	0.114	S. 86° W.	11.4	
4 46.0	8,000		−14.5		6	0.087	N. 81° W.	11.6	
4 46.8	8,210	280.5	−16.0	0.73	6	0.077	N. 73° W.	12.1	
4 49.0	8,636	265.3	−17.9	0.45	9	0.098	N. 80° W.	10.3	
4 50.5	9,000		−20.5		8	0.068	N. 59° W.	8.8	
4 55.1	10,010	220.3	−27.6	0.71	5	0.024	S. 87° W.	8.4	
5 0021	11,000		−34.2		4	0.009	N. 66° W.	10.5	
5 01.8	11,246	185.5	−35.9	0.67	4	0.007	N. 57° W.	10.0	
5 04.7	12,000		−40.8		3	0.003	N. 41° W.	10.7	
5 08.7	12,941	145.5	−47.0	0.65	2	0.001	N. 33° W.	13.7	
5 08.9	13,000		−47.2		2	0.001	N. 33° W.	13.6	
5 13.0	14,000		−51.2		2	0.001	N. 42° W.	9.8	
5 13.7	*14,200		−52.0	0.40	2	0.001	N. 45° W.	9.4	
5 15.7	*14,700		−51.5	−0.10	2	0.001	N. 55° W.	9.1	
5 16.9	15,000		−50.4		2	0.001	N. 61° W.	9.7	
5 19.2	*15,600		−48.3	−0.36	2	0.001	N. 81° W.	5.5	
5 20.7	16,000		−48.3		2	0.001	N. 81° W.	4.2	
5 22.4	*16,430		−48.3	0.00	2	0.001	N. 61° W.	6.0	
5 24.3	*16,950		−45.2	−0.60	2	0.001	N. 6° E.	3.8	
5 24.5	17,000						N. 16° E.	3.4	
5 26.0	*17,390						N. 29° E.	3.0	
5 27.0	*17,660						N. 20° E.	3.7	Few Cu., sw.
5 28.0	*17,920								Balloon burst.

JULY 14, 1914.

Time.	Altitude.	Pressure.	Temperature.	$\triangle t$ 100 m.	Relative.	Absolute.	Direction.	Velocity.	Remarks.
P. M.									
4 04.0	312	731.5	28.9		54	15.278	N. 11° E.	1.8	2/10 Ci., no move-
4 05.1	500		27.9		53	14.196	N. 6° E.	2.0	ment.
4 07.8	872	686.3	26.0	0.51	50	12.054	N. 4° W.	1.5	
4 08.3	1,000		24.9		51	11.560	N. 2° W.	1.4	
4 11.3	1,457	641.6	21.1	0.84	53	9.671	N. 4° W.	1.1	
4 11.5	1,500		21.0		51	9.252	N. 5° W.	1.3	
4 13.2	1,781	617.9	20.5	0.19	40	7.049	N. 9° W.	2.7	
4 14.4	2,000		20.4		33	5.782	N.21° W.	2.8	
4 17.0	2,481	569.4	20.2	0.04	19	3.290	N. 4° E.	2.2	
4 17.2	2,500		20.1		19	3.271	N. 2° W.	2.1	
4 20.1	3,000		16.6		15	2.087	N.32° W.	3.8	
4 22.3	3,500		13.0		11	1.237	N.53° W.	3.6	
4 22.4	3,543	502.5	12.8	0.71	11	1.222	N.54° W.	3.5	

* Pressure trace obliterated; altitudes computed from triangulation observations.

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 14, 1914—Continued.

Time.	Altitude.	Pressure.	Temperature.	Δt 100 m.	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
4 23.8	3,789	488.0	11.9	0.37	10	1.051	N.58° W.	3.7	
4 25.1	4,000	....	10.2	....	10	0.939	N.54° W.	4.7	
4 27.4	4,500	....	6.1	....	9	0.654	N. 6° W.	3.1	
4 28.9	4,894	426.8	3.8	0.81	8	0.500	N.	3.7	
4 29.8	5,000	....	3.3	....	8	0.483	N. 1° E.	3.6	
4 32.5	5,595	391.4	0.3	0.50	7	0.345	N. 7° E.	3.7	
4 34.1	6,000	....	− 1.1	....	6	0.266	N. 20° W.	4.6	
4 35.5	6,277	359.6	− 2.0	0.34	6	0.248	N.53° W.	5.3	
4 38.2	7,000	....	− 7.3	....	4	0.107	N.75° W.	5.4	
4 38.5	7,100	323.8	− 8.0	0.73	4	0.101	N.73° W.	5.3	
4 42.3	8,000	....	−13.9	....	5	0.077	N.42° W.	5.4	
4 42.8	8,148	282.7	−14.9	0.66	5	0.070	N.41° W.	5.6	
4 46.2	9,000	....	−20.1	....	5	0.044	N.46° W.	8.9	
4 46.5	9,086	249.7	−20.6	0.61	5	0.042	N.46° W.	9.1	
4 50.0	10,000	....	−26.5	....	5	0.024	N.41° W.	13.1	
4 51.0	10,309	211.4	−28.6	0.65	5	0.019	N.39° W.	14.5	
4 52.2	10,604	203.0	−29.9	0.44	5	0.017	N.42° W.	14.0	
4 53.8	11,000	....	−32.2	....	4	0.011	N.44° W.	13.6	
4 55.6	11,539	178.2	−35.2	0.57	3	0.006	N.45° W.	13.8	
4 57.6	12,000	....	−38.2	....	3	0.004	N.46° W.	14.8	
4 59.0	12,390	157.7	−40.7	0.65	3	0.003	N.49° W.	16.1	
5 01.4	13,000	....	−43.7	....	3	0.002	N.50° W.	18.5	
5 02.0	13,074	142.9	−44.1	0.50	3	0.002	N.48° W.	18.4	
5 05.0	13,964	125.5	−49.0	0.55	3	0.001	N.46° W.	17.0	
5 05.3	14,000	....	−49.2	....	3	0.001	N.46° W.	17.9	
5 07.1	14,567	114.8	−51.6	0.43	3	0.001	N.32° W.	19.4	
5 08.8	15,000	....	−51.8	....	3	0.001	N.34° W.	11.7	
5 08.9	15,031	106.8	−51.8	0.04	3	0.001	N.35° W.	11.2	
5 11.1	15,814	95.0	−52.4	0.08	3	0.001	N.54° W.	8.2	
5 12.2	16,000	....	−52.3	....	3	0.001	N.38° W.	6.9	
5 14.6	16,684	83.4	−51.8	−0.07	3	0.001	N.28° E.	4.4	
5 15.3	17,000	....	−51.4	....	3	0.001	N.48° E.	4.0	
5 18.0	17,851	69.7	−50.4	−0.12	3	0.001	N.84° E.	4.6	
5 18.3	18,000	....	−49.7	....	3	0.001	N.83° E.	4.7	
5 20.7	18,794	60.8	−45.9	−0.48	3	0.002	S.76° E.	3.5	
5 21.1	19,000	....	−45.6	....	3	0.002	S.75° E.	3.2	
5 23.3	19,853	52.0	−44.4	−0.14	3	0.002	N.57° E.	4.6	1/10 Ci., no movement.
5 24.1	20,000	....	−44.0	....	3	0.002	N.68° E.	6.9	
5 27.2	20,770	45.4	−42.1	−0.25	3	0.003	N.88° E.	5.8	3/10 A. St., nw.
5 28.8	21,000	....	−40.7	....	3	0.003	S.71° E.	4.7	
5 30.5	21,358	41.8	−38.6	−0.60	3	0.004	....	....	Balloon burst.

JULY 15, 1914.

Time.	Altitude.	Pressure.	Temperature.	Δt 100 m.	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
P. M.									
4 02.0	312	725.9	32.0	....	57	19.064	S. 2° E.	5.3	1/10 A. Cu., w.
4 03.2	500	....	32.4	....	48	16.400	S. 9° E.	4.9	
4 03.5	573	705.1	32.6	−0.23	45	15.539	S. 12° E.	4.7	1/10 St. Cu., sw.
4 05.3	727	693.1	31.2	0.91	45	14.420	S. 18° E.	8.3	
4 08.0	1,000	....	27.4	....	49	12.767	S. 12° E.	6.1	
4 09.0	1,104	664.2	25.9	1.41	51	12.227	S. 8° E.	5.2	
4 12.5	1,492	634.9	22.0	1.01	58	11.148	S. 20° W.	6.0	
4 16.3	1,998	598.9	17.4	0.91	71	10.426	S. 60° W.	10.8	
4 18.7	2,337	575.6	17.4	0.00	63	9.251	S.77° W.	12.4	
4 20.0	2,500	....	16.2	....	62	8.474	S. 74° W.	12.4	
4 21.5	2,786	545.6	14.1	0.73	59	7.100	S. 70° W.	11.9	
4 23.4	3,000	....	13.5	....	54	6.264	S. 74° W.	10.4	
4 24.8	3,243	517.0	12.9	0.26	49	5.478	N. 89° W.	9.2	
4 26.6	3,500	....	10.9	....	48	4.739	N. 83° W.	9.9	
4 28.2	3,768	485.0	8.8	0.78	47	4.064	N. 78° W.	10.1	Light rain from 4:28 to 4:30 p.m.
4 29.2	4,000	....	7.2	....	48	3.745	N. 76° W.	9.9	
4 30.7	4,500	....	3.7	....	51	3.165	N. 85° W.	8.3	
4 30.9	4,529	442.2	3.5	0.70	51	3.123	N. 86° W.	8.1	
4 34.0	4,766	429.4	− 1.0	1.90	60	2.681	N. 86° W.	11.2	Balloon entered cloud layer.
4 35.2	5,000	....	− 1.7	....	65	2.749	....	....	
4 38.6	5,418	395.6	− 3.0	0.31	73	2.783	....	....	
4 42.5	5,875	373.6	− 4.0	0.22	72	2.533	....	....	
4 43.3	6,000	....	− 4.5	....	70	2.366	....	....	
4 44.0	6,113	362.4	− 5.0	0.42	69	2.238	....	....	
4 45.3	6,319	353.1	− 5.0	0.00	65	2.109	....	....	
4 48.1	6,810	331.7	− 8.6	0.73	62	1.498	....	....	
4 49.3	7,000	....	− 9.8	....	59	1.292	....	....	
4 50.7	7,242	313.6	−11.4	0.65	56	1.070	....	....	
4 53.2	7,529	302.1	−12.5	0.38	54	0.936	....	....	
4 54.9	7,818	291.2	−14.8	0.80	54	0.766	....	....	
4 56.8	8,000	....	−15.7	....	54	0.710	....	....	
4 56.0	8,113	279.9	−16.2	0.47	54	0.680	....	....	
4 59.4	8,537	264.7	−18.7	0.59	50	0.504	....	....	
5 00.3	8,666	260.3	−18.5	−0.16	50	0.501	....	....	
5 02.5	9,000	....	−20.4	....	50	0.429	....	....	
5 03.8	9,259	240.5	−21.9	0.57	50	0.372	....	....	
5 07.6	9,858	221.8	−25.5	0.60	48	0.254	....	....	
5 08.7	10,000	....	−25.7	....	47	0.244	....	....	
5 09.4	10,129	213.7	−25.8	0.11	47	0.242	....	....	
5 11.9	10,599	200.0	−29.9	0.87	47	0.163	....	....	
5 14.3	11,000	189.2	−31.3	0.35	47	0.141	....	....	
5 15.8	11,257	182.7	−33.4	0.82	47	0.114	....	....	
5 17.3	11,538	175.6	−34.5	0.39	47	0.106	....	....	
5 18.3	11,748	170.5	−36.9	1.14	47	0.079	....	....	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 16, 1914.

Time.	Altitude.	Pressure.	Temperature.	Δt 100 m.	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
4 00.5	312	729.9	25.0	....	70	16.688	N. 15° E.	6.1	9/10 St. Cu., wsw.
4 01.3	500	....	....	....	....	....	N. 15° E.	6.1	
4 04.0	1,000	....	....	....	....	....	N. 7° E.	16.2	Meteorograph clock stopped at beginning of ascension.
4 06.8	1,500	....	....	....	....	....	N. 6° E.	19.8	
4 09.3	2,000	....	....	....	....	....	N. 3° W.	4.8	
4 12.0	2,500	....	....	....	....	....	N. 66° W.	9.3	
4 14.3	3,000	....	....	....	....	....	N. 84° W.	14.4	
4 16.7	3,500	....	....	....	....	....	N. 89° W.	18.6	
4 19.0	4,000	....	....	....	....	....	S. 79° W.	16.9	
4 21.1	4,500	....	....	....	....	....	S. 79° W.	19.6	
4 23.2	5,000	....	....	....	....	....	S. 72° W.	22.6	
4 26.8	6,000	....	....	....	....	....	S. 72° W.	26.1	
4 30.1	7,000	....	....	....	....	....	S. 87° W.	25.5	
4 33.0	8,000	....	....	....	....	....	N. 86° W.	26.1	
4 35.6	9,000	....	....	....	....	....	N. 88° W.	21.4	
4 37.9	10,000	....	....	....	....	....	N. 84° W.	22.0	
4 40.0	11,000	....	....	....	....	....	S. 89° W.	34.9	
4 42.1	12,000	....	....	....	....	....	S. 85° W.	27.6	
4 44.2	13,000	....	....	....	....	....	S. 74° W.	21.4	
4 46.6	14,000	....	....	....	....	....	S. 78° W.	25.3	
4 48.8	15,000	....	....	....	....	....	S. 81° W.	25.2	
4 51.1	16,000	....	....	....	....	....	S. 82° W.	16.2	
4 53.3	17,000	....	....	....	....	....	S. 77° W.	13.3	

JULY 17, 1914 (Series No. 1).

Time.	Altitude.	Pressure.	Temperature.	Δt 100 m.	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
P. M.									
12 30.5	312	736.6	28.4	....	24	6.607	N. 38° W.	7.0	2/10 A. Cu., w.
12 31.6	500	....	26.9	....	23	5.829	N. 45° W.	8.5	
12 32.5	646	709.1	25.8	0.78	23	5.483	N. 50° W.	9.8	
12 34.2	1,000	....	22.3	....	24	4.693	N. 44° W.	7.5	
12 35.1	1,245	661.8	19.8	1.00	25	4.230	N. 48° W.	10.4	
12 36.9	1,500	....	16.8	....	27	3.825	N. 46° W.	12.1	
12 38.5	1,783	621.0	13.4	1.19	30	3.459	N. 50° W.	11.7	
12 39.6	2,000	....	11.5	....	31	3.178	N. 53° W.	11.1	
12 42.3	2,500	....	7.1	....	34	2.636	N. 38° W.	14.3	
12 42.7	2,599	562.6	6.2	0.88	35	2.560	N. 33° W.	15.6	
12 44.3	2,852	545.7	7.7	−0.59	32	2.579	N. 32° W.	18.8	
12 45.3	3,000	....	7.6	....	30	2.402	N. 34° W.	19.4	
12 48.2	3,500	....	7.4	....	25	1.976	N. 36° W.	13.9	
12 49.3	3,703	492.2	7.3	0.00	23	1.806	N. 38° W.	12.3	
12 50.6	3,974	475.8	4.9	0.89	22	1.478	N. 48° W.	15.3	
12 51.1	4,000	....	4.7	....	22	1.459	N. 52° W.	16.6	
12 54.5	4,318	456.3	2.7	0.64	21	1.219	N. 68° W.	22.7	
12 55.4	4,500	....	2.1	....	20	1.115	N. 71° W.	19.9	
12 57.9	4,844	427.3	0.9	0.34	19	0.977	N. 75° W.	12.5	
12 58.6	5,000	....	− 1.2	....	20	0.880	N. 75° W.	12.5	
12 59.4	5,123	412.6	− 2.9	1.36	20	0.769	N. 74° W.	13.5	
1 03.4	5,728	382.2	− 7.1	0.69	20	0.546	N. 71° W.	26.4	
1 05.2	6,000	....	− 8.8	....	21	0.499	N. 73° W.	24.3	
1 07.2	6,274	356.5	−10.6	0.78	22	0.450	N. 77° W.	20.1	
1 09.7	6,726	335.9	−14.3	0.81	24	0.355	N. 83° W.	19.5	1/10 A. Cu., w.
1 11.8	7,000	....	−15.3	....	24	0.326	N. 86° W.	22.6	
1 14.0	7,330	310.4	−16.5	0.36	23	0.283	N. 86° W.	25.0	
1 17.5	7,829	290.3	−20.0	0.70	23	0.205	N. 87° W.	26.9	
1 18.4	8,000	....	−20.9	....	23	0.188	N. 86° W.	25.3	
1 21.6	8,545	263.8	−23.7	0.52	24	0.151	N. 81° W.	26.9	
1 24.3	9,000	....	−25.2	....	24	0.131	N. 82° W.	28.6	
1 26.8	9,430	233.6	−26.6	0.33	24	0.114	N. 83° W.	36.3	
1 29.8	10,000	....	−32.0	....	23	0.064	N. 83° W.	35.0	
1 31.3	10,272	207.7	−34.6	0.95	23	0.049	N. 83° W.	35.5	
1 35.0	11,000	....	−39.4	....	23	0.029	S. 89° W.	32.4	
1 35.5	11,093	184.8	−40.0	0.66	23	0.027	S. 89° W.	32.7	
1 38.3	11,770	167.4	−43.2	0.47	23	0.019	S. 86° W.	36.0	
1 39.7	12,000	....	−44.5	....	22	0.016	S. 85° W.	37.9	
1 41.7	12,539	149.6	−47.5	0.56	21	0.011	S. 87° W.	37.1	
1 42.5	12,778	144.3	−47.1	−0.17	21	0.011	S. 85° W.	34.8	
1 43.8	13,000	....	−48.2	....	21	0.010	....	....	
1 46.0	13,536	128.8	−50.7	0.47	21	0.007	....	....	
1 46.5	13,684	126.1	−50.4	−0.20	21	0.008	....	....	
1 47.8	14,000	....	−51.7	....	21	0.007	....	....	
1 50.0	14,585	110.2	−54.1	0.41	21	0.005	....	....	
1 51.0	15,000	....	−54.8	....	21	0.005	....	....	
1 53.7	15,965	89.1	−56.6	0.18	21	0.004	....	....	
1 54.0	16,000	....	−56.4	....	21	0.004	....	....	
1 54.9	16,298	84.4	−55.0	−0.48	22	0.005	....	....	
1 56.7	16,953	76.5	−55.1	0.02	22	0.005	....	....	
1 56.9	17,000	....	−54.9	....	22	0.005	....	....	
1 59.5	17,923	66.0	−50.7	−0.45	22	0.008	....	....	
1 59.9	18,000	....	−50.8	....	22	0.008	....	....	
2 00.6	18,295	62.4	−51.0	0.08	23	0.008	....	....	
2 03.2	19,000	....	−48.6	....	23	0.011	....	....	
2 04.5	19,314	53.5	−47.5	−0.34	23	0.012	....	....	
2 06.9	20,000	....	−46.6	....	23	0.013	....	....	
2 07.3	20,068	47.8	−46.5	−0.13	23	0.013	....	....	
2 10.5	21,000	....	−43.4	....	22	0.018	....	....	
2 12.5	21,521	38.6	−41.7	−0.33	22	0.022	....	....	
2 14.3	22,000	....	−40.6	....	23	0.026	....	....	
2 16.1	22,387	34.0	−39.6	−0.24	24	0.030	....	....	
2 18.3	23,000	....	−39.4	....	24	0.031	....	....	
2 19.6	23,320	....	−39.3	−0.03	24	0.031	....	....	Pressure pen not recording; altitudes determined by extrapolation.
2 24.5	24,500	....	−36.0	−0.27	25	0.046	....	....	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr*—Continued.

JULY 17, 1914 (Series No. 2).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\text{ m.}}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
3 00.0	312	736.4	29.3	......	23	6.651	N.14° W.	8.7	Few A.Cu., w.
3 01.1	436	726.2	30.4	−0.82	23	7.059	N.24° W.	9.7	
3 01.4	500	......	29.7	......	23	6.797	N.28° W.	10.1	
3 03.9	938	686.0	24.9	1.10	24	5.440	N.39° W.	7.4	
3 04.2	1,000	......	24.2	......	24	5.229	N.39° W.	6.8	
3 06.5	1,500	......	18.5	......	25	3.918	N.42° W.	9.1	
3 08.4	1,961	608.6	13.3	1.13	26	2.979	N.56° W.	7.6	
3 09.1	2,000	......	13.0	......	26	2.925	N.64° W.	7.1	
3 12.2	2,464	572.8	8.9	0.87	29	2.523	N.47° W.	8.0	
3 12.4	2,500	......	8.7	......	29	2.491	N.46° W.	7.7	
3 13.4	2,748	553.6	7.0	0.67	28	2.157	N.38° W.	10.7	
3 15.3	3,000	......	7.4	......	27	2.134	N.36° W.	14.3	
3 16.4	3,220	522.5	7.8	−0.17	27	2.190	N.38° W.	15.0	
3 18.7	3,500	......	5.8	......	25	1.781	N.43° W.	15.3	
3 19.1	3,542	502.5	5.5	0.71	25	1.747	N.45° W.	15.6	
3 20.3	3,740	490.5	5.8	−0.15	24	1.710	N.53° W.	16.0	
3 21.7	4,000	......	4.9	......	22	1.478	N.69° W.	14.9	
3 22.0	4,055	471.9	4.7	0.35	22	1.459	N.69° W.	15.0	
3 24.3	4,496	447.0	1.7	0.68	21	1.140	N.65° W.	17.3	
3 27.4	5,000	......	− 2.5	......	21	0.833	N.66° W.	17.7	
3 27.8	5,098	414.4	− 3.3	0.83	21	0.782	N.66° W.	17.6	
3 28.6	5,250	406.7	− 5.0	1.12	21	0.681	N.67° W.	17.4	
3 33.0	6,000	......	− 8.9	......	19	0.448	N.70° W.	21.8	
3 33.4	6,079	365.7	− 9.3	0.52	19	0.434	N.70° W.	21.8	Cloudless.
3 38.0	6,946	326.6	−13.6	0.50	19	0.299	N.80° W.	24.1	
3 38.3	7,000	......	−14.0	......	19	0.289	N.80° W.	24.6	
3 39.6	7,308	311.4	−16.3	0.75	18	0.225	N.79° W.	23.6	
3 40.0	7,490	304.0	−18.6	1.26	18	0.183	N.79° W.	19.0	
3 43.3	8,000	......	−22.1	......	18	0.131	N.83° W.	28.8	
3 44.0	8,100	280.1	−22.8	0.69	18	0.123	N.81° W.	29.0	
3 47.8	8,954	249.6	−27.9	0.60	18	0.075	N.78° W.	30.8	
3 48.0	9,000	......	−28.2	......	18	0.073	N.78° W.	30.6	
3 51.6	9,806	221.4	−34.3	0.75	18	0.040	N.81° W.	36.8	
3 52.3	10,000	......	−35.8	......	18	0.034	N.85° W.	32.8	
3 55.6	10,742	193.8	−41.7	0.79	17	0.017	N.89° W.	31.1	
3 56.8	11,000	......	−43.7	......	17	0.013	N.83° W.	36.1	
3 59.9	11,734	167.4	−49.3	0.77	16	0.007	S. 85° W.	31.8	
4 01.1	12,000	......	−50.9	......	16	0.005	S. 86° W.	31.6	
4 03.0	12,486	149.6	−53.9	0.61	16	0.004	S. 84° W.	32.6	
4 05.5	13,000	......	−55.6	......	15	0.003	S. 77° W.	22.5	
4 06.4	13,364	131.0	−56.9	0.34	15	0.002	S. 86° W.	27.0	
4 07.3	13,552	127.1	−58.3	0.74	15	0.002	N.89° W.	29.1	
4 10.1	14,000	......	−59.6	......	14	0.002	N.87° W.	19.2	
4 11.2	14,307	113.4	−60.5	0.29	14	0.001	N.87° W.	14.8	
4 14.6	15,000	......	−60.5	......	14	0.001	S. 82° W.	22.9	
4 15.7	15,141	99.3	−60.5	0.00	14	0.001	W.	23.1	
4 18.2	15,936	87.8	−59.9	−0.08	14	0.001	S. 48° W.	9.0	
4 18.4	16,000	......	−59.6	......	14	0.002	S. 38° W.	7.7	
4 20.0	16,449	81.1	−57.8	−0.41	15	0.002	S. 35° E.	8.6	
4 21.1	16,832	76.4	−56.9	−0.23	15	0.002	S. 79° E.	13.4	
4 22.1	17,000	......	−55.5	......	15	0.003	Calm.	0.0	
4 22.7	17,099	73.1	−54.6	−0.86	15	0.003	N.79° W.	1.2	
4 24.4	17,675	67.2	−54.8	0.03	15	0.003	N.76° W.	6.4	
4 26.0	18,000	......	−53.4	......	15	0.004	Calm.	0.0	
4 27.9	18,496	59.2	−51.2	−0.44	15	0.005	N.	6.6	
4 30.1	19,000	......	−49.3	......	15	0.006	N.3° E.	4.2	
4 30.9	19,191	53.3	−48.6	−0.37	15	0.007	N.60° W.	6.7	
4 32.0	19,447	51.3	−46.2	−0.94	15	0.009	Calm.	0.0	
4 33.8	19,903	48.0	−44.9	−0.29	15	0.010	S. 83° E.	14.2	
4 34.2	20,000	......	−44.0	......	15	0.011	S. 83° E.	14.2	
4 34.5	**20,080**	46.7	−43.2	−0.96	15	0.013	......	......	Balloon burst.

JULY 17, 1914 (Series No. 3).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\text{ m.}}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
5 31.0	312	735.8	28.4	......	30	8.259	N. 4° E.	3.7	Few St.Cu. on northern horizon.
5 32.3	500	......	27.9	......	29	7.767	N. 5° W.	4.5	
5 32.6	569	714.6	27.7	0.27	28	7.417	N. 7° W.	4.6	
5 35.5	905	687.7	23.8	1.16	29	6.177	N.24° W.	6.3	
5 36.2	1,000	......	22.7	......	30	6.002	N.31° W.	6.4	
5 38.7	1,222	662.9	20.3	1.10	31	5.400	N.39° W.	5.8	
5 40.0	1,500	......	17.5	......	35	5.170	N.40° W.	5.4	
5 43.2	1,933	609.7	13.1	1.01	40	4.527	N.38° W.	6.9	
5 43.6	2,000	......	12.5	......	41	4.472	N.40° W.	7.3	
5 45.5	2,303	583.3	9.9	0.86	44	4.079	N.44° W.	9.2	
5 47.0	2,500	......	9.9	......	38	3.523	N.36° W.	11.2	
5 50.3	2,938	540.2	9.9	0.00	24	2.225	N.43° W.	14.3	
5 50.5	3,000	......	9.6	......	24	2.183	N.44° W.	14.2	
5 53.8	3,500	......	7.5	......	22	1.750	N.59° W.	11.9	
5 55.7	3,835	484.6	6.0	0.43	21	1.516	N.63° W.	12.9	
5 56.9	4,000	......	4.4	......	20	1.300	N.64° W.	13.0	
5 57.4	4,116	468.0	3.3	0.96	19	1.148	N.64° W.	15.5	
5 59.6	4,346	455.1	3.0	0.13	19	1.125	N.62° W.	20.0	
6 00.4	4,500	......	1.8	......	18	0.984	N.61° W.	19.5	
6 04.1	5,000	......	− 2.0	......	17	0.702	N.63° W.	17.4	
6 05.3	5,158	411.1	− 3.2	0.76	16	0.601	N.64° W.	18.1	
6 06.7	5,336	401.9	− 3.2	0.00	15	0.563	N.70° W.	14.0	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr*—Continued.

JULY 17, 1914 (Series No. 3)—Continued.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\text{ m.}}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
6 10.1	6,002	369.3	− 6.5	0.50	13	0.373	N.66° W.	17.4	
6 15.8	6,722	336.7	−12.6	0.85	12	0.206	N.77° W.	19.3	
6 18.0	7,000	......	−14.5	......	13	0.189	N.80° W.	22.6	
6 22.8	7,721	295.2	−19.4	0.68	16	0.151	N.78° W.	28.5	
6 24.8	8,000	......	−21.5	......	16	0.124	N.76° W.	28.3	
6 28.2	8,602	261.4	−26.2	0.77	16	0.079	N.81° W.	27.3	
6 31.1	9,000	......	−30.0	......	16	0.055	N.82° W.	29.6	
6 32.9	9,293	238.2	−32.8	0.96	16	0.041	N.81° W.	22.5	
6 37.7	10,000	......	−39.9	......	14	0.017	......	......	
6 38.1	10,120	211.8	−40.5	1.00	14	0.016	......	......	
6 42.0	10,551	199.2	−46.0	1.28	14	0.009	......	......	
6 44.3	10,911	188.7	−48.4	0.67	14	0.007	......	......	
6 44.7	11,000	......	−48.7	......	14	0.006	......	......	
6 50.0	12,000	......	−51.9	......	12	0.004	......	......	
6 50.7	12,142	157.1	−52.3	0.32	12	0.003	......	......	
6 55.0	13,000	......	−55.8	......	11	0.002	......	......	
6 56.1	13,246	132.7	−56.8	0.41	11	0.002	......	......	
7 00.0	14,000	......	−57.9	......	11	0.002	......	......	
7 02.4	14,583	108.1	**−58.7**	0.14	11	0.001	......	......	
7 04.3	15,000	......	−57.2	......	11	0.002	......	......	
7 07.2	15,580	92.7	−55.2	−0.35	11	0.002	......	......	
7 08.3	16,000	......	−54.0	......	11	0.003	......	......	
7 12.0	17,000	......	−51.1	......	11	0.004	......	......	
7 12.3	17,089	73.7	−50.8	−0.29	11	0.004	......	......	
7 15.5	18,000	......	−48.7	......	11	0.005	......	......	
7 17.4	18,678	58.0	−47.2	−0.23	11	0.006	......	......	
7 19.0	19,000	......	−47.1	......	11	0.006	......	......	
7 22.0	19,970	47.8	−46.7	−0.04	11	0.006	......	......	
7 22.1	20,000	......	−46.7	......	11	0.006	......	......	
7 24.4	20,514	44.2	−46.6	0.00	11	0.00[illegible]	......	......	
7 25.0	21,000	......	−44.2	......	11	0.008	......	......	
7 27.0	22,000	......	−39.2	......	11	0.01[illegible]	......	......	
7 28.7	22,992	30.8	−34.1	−0.50	11	0.025	......	......	Few St.Cu. on northern horizon.
7 30.3	24,000	......	−31.8	......	11	0.031	......	......	
7 31.5	25,000	......	−29.5	......	11	0.039	......	......	
7 32.4	**25,953**	20.3	−27.4	−0.23	11	0.048	......	......	Balloon burst.

JULY 17, 1914 (Series No. 4).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\text{ m.}}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
P. M.									
8 10.0	312	735.6	24.2	......	43	9.369	N. 11° E.	4.[illegible]	Few A.St. on northern horizon.
8 11.1	500	......	25.7	......	41	9.720	N. 13° E.	3.8	
8 11.3	555	715.3	26.1	−0.78	40	9.697	N. 14° E.	3.5	
8 13.9	1,000	......	22.1	......	38	7.346	N. 11° W.	7.3	
8 14.1	1,043	676.3	21.7	0.90	38	7.179	N. 16° W.	7.0	
8 16.8	1,500	......	17.9	......	40	6.051	N. 48° W.	6.5	
8 17.0	1,531	638.9	17.6	0.84	40	5.944	N. 49° W.	6.5	
8 19.6	2,000	......	12.1	......	43	4.575	N. 49° W.	9.6	
8 19.9	2,040	601.4	11.6	1.18	44	4.538	N. 48° W.	10.4	
8 22.3	2,500	......	9.4	......	45	4.042	N. 38° W.	14.5	
8 23.3	2,685	556.2	8.5	0.48	46	3.902	N. 37° W.	14.9	
8 25.1	3,000	......	8.2	......	39	3.245	N. 42° W.	12.8	
8 25.4	3,092	529.7	8.1	0.10	35	2.894	N. 42° W.	12.6	
8 27.9	3,500	......	4.4	......	31	2.015	N. 48° W.	11.9	
8 28.1	3,562	500.0	3.8	0.91	30	1.874	N. 50° W.	12.1	
8 30.0	3,870	481.3	1.7	0.68	30	1.628	......	......	
8 31.0	4,000	......	1.4	......	30	1.595	......	......	
8 32.3	4,163	464.2	1.0	0.24	30	1.553	......	......	
8 34.0	4,500	......	− 0.4	......	29	1.359	......	......	
8 34.9	4,635	437.6	− 1.0	0.42	28	1.251	......	......	
8 36.8	5,000	......	− 3.5	......	25	0.916	......	......	
8 37.7	5,189	408.2	− 4.8	0.69	24	0.792	......	......	
8 41.0	5,746	380.1	− 7.3	0.45	22	0.591	......	......	
8 42.8	6,000	......	− 9.4	......	22	0.498	......	......	
8 46.1	6,508	344.5	−13.7	0.84	22	0.343	......	......	
8 49.0	7,000	......	−16.4	......	24	0.297	......	......	
8 50.0	7,188	314.9	−17.4	0.54	25	0.284	......	......	
8 54.3	7,796	290.3	−22.4	0.82	25	0.177	......	......	
8 55.9	8,000	......	−24.0	......	24	0.147	......	......	
8 59.0	8,461	265.4	−27.5	0.77	23	0.100	......	......	
9 03.0	9,000	......	−31.4	......	23	0.069	......	......	
9 04.3	9,160	240.8	−32.5	0.72	23	0.061	......	......	
9 09.3	9,835	219.0	−38.2	0.84	25	0.036	......	......	
9 10.6	10,000	......	−39.6	......	25	0.031	......	......	
9 14.7	10,480	199.1	−43.7	0.85	25	0.020	......	......	
9 18.3	10,864	188.2	−46.8	0.81	25	0.014	......	......	
9 19.1	11,000	......	−47.3	......	25	0.013	......	......	
9 21.6	11,318	176.2	−48.5	0.37	25	0.012	......	......	
9 26.5	11,935	160.6	−52.5	0.65	25	0.007	......	......	
9 27.5	12,000	......	−52.6	......	25	0.007	......	......	
9 30.2	12,341	151.3	−53.4	0.22	25	0.006	......	......	
9 33.1	12,600	145.5	−55.1	0.66	25	0.005	......	......	
9 33.8	12,737	142.4	−55.2	0.07	25	0.005	......	......	
9 34.6	12,951	137.7	−55.3	0.05	25	0.005	......	......	
9 34.8	13,000	......	−55.3	......	25	0.005	......	......	
9 35.1	13,097	134.6	**−55.4**	0.07	25	0.005	......	......	Clock stopped.
......	**16,570**	79.5	−49.5	−0.17	25	0.010	......	......	Balloon burst.

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 17 AND 18, 1914 (Series No. 5).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Humidity.		Wind.		Remarks.
					Relative.	Absolute.	Direction.	Velocity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
10 34.0	312	736.6	16.7		77	10.844	N. 32° E.	7.6	Cloudless.
10 34.4	429	726.6	21.0	−3.68			N. 32° E.	7.6	
10 35.0	500		22.4				N. 32° E.	7.6	
10 35.3	514	719.5	22.7	−2.00			N. 32° E.	7.6	
10 36.2	688	705.2	22.7	0.00			N. 32° E.	7.6	
10 38.2	1,000		20.7				N. 11° E.	5.6	
10 38.6	1,074	674.3	20.2	0.65			N. 2° E.	5.4	
10 40.5	1,398	649.3	18.5	0.52			N.35° W.	6.4	
10 41.1	1,500		17.8				N.46° W.	7.0	
10 44.0	2,000		14.4				N.46° W.	11.2	
10 45.2	2,219	589.3	12.9	0.68			N.50° W.	12.9	
10 46.5	2,500		10.9				N.46° W.	15.3	
10 47.1	2,607	562.5	10.2	0.70			N.43° W.	16.2	
10 49.4	2,948	539.7	8.2	0.59			N.34° W.	14.7	
10 50.1	3,000		7.8				N.35° W.	14.5	
10 51.7	3,277	518.5	5.5	0.82			N.38° W.	14.2	
10 53.0	3,507	504.0	5.1	0.17			N.41° W.	14.2	
10 54.0	3,613	497.4	5.5	−0.38			N.42° W.	14.2	
10 56.3	4,000		3.2				N.48° W.	14.8	
10 58.0	4,291	457.8	1.4	0.60			N.57° W.	12.9	
10 59.5	4,500		0.0				N.61° W.	11.7	
11 01.7	4,856	426.3	− 2.4	0.67			N.57° W.	13.1	
11 02.5	5,000		− 3.2				N.58° W.	12.3	
11 05.5	5,495	393.4	− 5.8	0.53			N.61° W.	16.0	
11 08.8	6,006	368.6	− 7.6	0.35			N.60° W.	16.1	
11 13.7	6,842	330.7	−13.4	0.69					
11 14.8	7,000		−14.4						
11 19.0	7,725	294.4	−19.1	0.65					
11 21.0	8,000		−20.5						
11 22.8	8,276	273.7	−22.0	0.52					
11 26.3	8,701	258.0	−24.3	0.54					
11 27.3	9,000		−26.3						
11 31.3	9,641	227.0	−30.6	0.67					
11 33.9	10,000		−33.2						
11 36.7	10,402	203.8	−36.1	0.72					
11 40.4	11,000		−40.3						
11 41.9	11,229	181.1	−42.0	0.71					
11 46.8	12,000		−46.2						
11 47.3	12,101	159.4	−46.7	0.54					
11 52.0	12,868	141.7	−50.6	0.51					
11 53.0	13,000		−51.2						
11 58.4	13,777	124.1	−54.9	0.47					
11 59.5	14,000		−55.7						
A. M.									
12 04.2	14,842	105.2	−58.5	0.34					
12 05.6	15,000		−58.5						
12 08.3	15,414	96.4	−58.7	0.03					
12 09.4	15,584	93.8	−59.7	0.59					
12 11.8	16,000		−59.0						
12 14.1	16,541	81.1	−58.1	−0.17					
12 17.4	16,830	77.6	−56.7	−0.48					
12 18.3	17,000		−56.4						
12 22.2	17,276	72.3	−56.0	−0.16					
12 26.3	**17,837**	67.1	−54.1	−0.34					

JULY 18, 1914 (Series No. 6).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Relative.	Absolute.	Direction.	Velocity.	Remarks.
A. M.									
1 07.0	312	736.9	18.3		71	10.998	N.60° E.	7.7	Cloudless.
1 07.6	488	721.8	19.2	−0.51	64	10.454	N.60° E.	7.7	
1 07.9	500		19.3		64	10.515	N.60° E.	7.7	
1 08.4	629	710.1	20.9	−1.21	59	10.642	N.60° E.	7.7	
1 09.7	895	688.4	20.9	0.00	50	9.018	N.46° E.	7.4	
1 10.3	1,000		20.4		49	8.585	N.41° E.	7.6	
1 12.7	1,500		17.8		43	6.466	N.79° W.	6.2	
1 13.2	1,640	631.0	17.1	0.51	41	5.914	N.63° W.	6.6	
1 15.1	2,000		13.8		41	4.844	N.51° W.	8.7	
1 16.3	2,220	589.1	11.7	0.93	41	4.255	N.60° W.	10.5	
1 17.5	2,500		10.0		43	4.011	N.52° W.	13.3	
1 19.7	2,991	536.7	7.0	0.61	47	3.620	N.38° W.	14.8	
1 22.5	3,500		3.0		55	3.257	N.33° W.	19.1	
1 23.3	3,734	489.8	1.1	0.79	59	3.075	N.35° W.	19.8	
1 24.2	3,839	483.5	1.3	−0.19	57	3.011	N.41° W.	19.0	
1 25.0	4,000		0.2		58	2.843	N.46° W.	18.3	
1 25.8	4,177	463.4	− 1.0	0.68	59	2.636	N.50° W.	16.7	
1 27.6	4,500		− 1.2		52	2.287	N.55° W.	14.4	
1 27.8	4,589	440.2	− 1.3	0.07	50	2.182	N.55° W.	14.5	
1 30.2	5,000		− 3.9		43	1.525	N.57° W.	16.1	
1 31.1	5,189	407.9	− 5.1	0.63	40	1.287	N.57° W.	16.8	
1 34.3	5,794	377.6	− 8.5	0.56	34	0.828	N.66° W.	14.2	
1 35.3	6,000		− 9.2		32	0.737	N.70° W.	14.2	
1 35.7	6,114	362.4	− 9.6	0.34	31	0.690	N.70° W.	14.2	
1 37.6	6,475	345.7	−10.4	0.22	26	0.541			
1 40.6	7,000		−13.0		23	0.381			
1 41.6	7,252	312.7	−14.2	0.49	22	0.328			
1 44.4	7,812	290.2	−17.9	0.66	26	0.283			
1 45.5	8,000		−19.1		28	0.272			

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TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 18, 1914 (Series No. 6)—Continued.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Humidity.		Wind.		Remarks.
					Relative.	Absolute.	Direction.	Velocity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
A. M.									
1 47.2	8,367	269.3	−21.4	0.63	31	0.241			Clock stopped, but ran again at high levels; intermediate values interpolated.
	9,000		−25.1		31	0.171			
	10,000		−31.0		32	0.099			
	11,000		−36.9		32	0.054			
	12,000		−42.8		33	0.029			
	13,000		−48.7		33	0.015			
	14,000		−54.6		34	0.007			
	15,000		−60.5		34	0.003			
	16,000		−66.4		34	0.001			
	16,076	87.2	−67.1	0.59	34	0.001			Clock running.
	16,372	83.0	−68.8	0.57	35	(*)			
	16,721	78.4	−68.9	0.03	34	(*)			
	17,000		−68.8		33	(*)			
	17,560	68.5	−68.7	−0.02	31	(*)			

JULY 18, 1914 (Series No. 7).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Relative.	Absolute.	Direction.	Velocity.	Remarks.
A. M.									
3 47.0	312	737.6	16.6		75	10.500	S. 85° E.	6.2	Few A.Cu.,wnw
3 47.5	474	723.7	18.9	−1.42	69	11.073	S. 85° E.	6.2	1/10 St.Cu.,wnw.
3 47.9	500		18.8		69	11.008	S. 85° E.	6.2	
3 48.7	639	709.8	18.2	0.42	68	10.471	S. 81° E.	7.0	
3 50.5	1,000		20.9		49	8.838	N.58° E.	4.8	
3 50.6	1,017	679.2	21.0	−0.74	48	8.708	N.53° E.	4.5	
3 51.8	1,232	662.4	20.4	0.28	42	7.359	N. 9° E.	3.9	
3 53.3	1,500		18.8		42	6.701	N.29° W.	5.6	
3 53.8	1,572	636.7	18.4	0.59	42	6.544	N.26° W.	6.8	
3 54.9	1,756	623.1	17.7	0.38	42	6.279	N.25° W.	8.8	
3 56.1	2,000		15.7		42	5.570	N.37° W.	9.2	
3 58.0	2,301	584.1	13.1	0.84	42	4.754	N.48° W.	10.2	
3 58.9	2,500		11.4		45	4.584	N.48° W.	11.6	
4 01.1	2,914	542.6	7.9	0.85	51	4.163	N.43° W.	12.3	
4 01.7	3,000		8.0		52	4.272	N.42° W.	12.0	
4 02.5	3,167	526.2	8.2	−0.12	55	4.577	N.41° W.	11.7	
4 04.3	3,500		6.0		55	3.970	N.35° W.	15.9	
4 05.8	3,781	488.1	4.2	0.65	55	3.528	N.37° W.	17.1	1/10 A.Cu.,wnw.
4 07.2	4,000		2.7		58	3.367	N.46° W.	15.8	1/10 St.Cu.,wnw.
4 08.9	4,382	453.2	0.1	0.68	63	3.067	N.59° W.	18.9	
4 10.0	4,500		0.0		58	2.804	N.66° W.	15.8	
4 11.0	4,696	435.8	− 0.2	0.10	51	2.427	N.67° W.	16.8	
4 12.7	5,000		− 1.7		45	1.903	N.67° W.	15.2	
4 14.0	5,268	405.8	− 3.0	0.49	40	1.525			3/10 A.Cu., wnw.
4 18.0	6,000		− 6.9		32	0.888			
4 18.2	6,021	368.6	− 7.0	0.53	32	0.881			
4 22.7	6,964	326.4	−11.9	0.52	32	0.585			
4 23.2	7,000		−12.1		32	0.574			
4 28.3	8,010	284.3	−17.6	0.54	41	0.458			
4 33.8	8,984	249.6	−24.3	0.69	47	0.280			
4 34.0	9,000		−24.3		47	0.280			
4 34.3	9,058	247.0	−24.3	0.00	47	0.280			
4 38.7	9,838	222.2	−29.7	0.69	47	0.165			
4 39.6	10,000		−30.7		46	0.147			
4 43.5	10,729	196.0	−35.1	0.61	44	0.089			
4 45.0	11,000		−37.3		43	0.069			
4 47.8	11,550	174.3	−41.7	0.80	42	0.042			
4 50.0	12,000		−44.1		40	0.030			
4 53.0	12,651	148.4	−47.6	0.54	38	0.019			
4 54.8	13,000		−49.0		38	0.017			
4 57.2	13,607	128.5	−51.3	0.39	38	0.013			
4 59.0	14,000		−54.4		38	0.009			
5 02.0	14,906	105.3	−61.4	0.78	39	0.003			
5 02.3	15,000		−61.5		39	0.003			
5 03.0	15,246	100.0	−61.9	0.15	40	0.003			
5 04.2	15,504	96.2	−61.0	−0,35	39	0.003			
5 05.2	16,000		−61.0		40	0.003			
5 05.5	**16,169**	86.6	−61.0	0.00	40	0.003			

JULY 18, 1914 (Series No. 8).

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Relative.	Absolute.	Direction.	Velocity.	Remarks.
A. M.									
6 05.0	312	738.8	16.7		77	10.844	S. 70° E.	2.7	2/10 A.Cu., wnw.
6 06.4	500						S. 66° E.	5.7	5/10 St.Cu., wnw.
6 10.1	1,000						N.87° E.	2.0	Meteorograph not returned.
6 13.8	1,500						N.27° W.	5.7	
6 17.4	2,000						N.42° W.	7.6	
6 21.0	2,500						N.47° W.	9.6	
6 24.4	3,000						N.35° W.	14.6	
6 27.8	3,500						N.38° W.	14.4	
6 31.0	4,000						N.47° W.	14.8	
6 34.0	4,500						N.58° W.	16.2	
6 37.0	5,000						N.66° W.	16.4	
6 40.0	5,210						N.76° W.	8.5	

*Less than 0.0005 g./cu. m.

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 18, 1914 (Series No. 9).

Time.	Alti-tude.	Pres-sure.	Tem-pera-ture.	Δt 100 m.	Humidity.		Wind.		Remarks.
					Rel-ative.	Abso-lute.	Direc-tion.	Ve-locity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
A. M.									
8 30.0	312	739.4	19.1	......	70	11.367	S. 70° E.	2.7	10/10 A. St., wnw.
8 31.0	500	......	18.1	......	70	10.716	S. 56° E.	4.0	Solar halo.
8 31.7	566	717.7	17.7	0.55	70	10.464	S. 40° E.	4.9	
8 32.7	707	705.9	19.2	−1.06	67	10.944	S. 34° E.	3.2	
8 34.1	953	685.9	18.8	0.16	60	9.572	S. 26° W.	2.2	
8 34.3	1,000	......	19.0	......	58	9.363	S. 36° W.	2.1	
8 34.9	1,079	675.9	19.2	−0.32	55	8.984	S. 68° W.	1.8	
8 36.8	1,500	......	18.1	......	49	7.501	N. 77° W.	4.5	
8 38.3	1,732	626.0	17.6	0.25	46	6.836	N. 58° W.	5.4	
8 39.7	2,000	......	15.6	......	49	6.459	N. 73° W.	6.2	
8 41.2	2,217	591.1	14.0	0.74	51	6.100	N. 69° W.	6.2	
8 42.5	2,500	......	12.7	......	57	6.294	N. 60° W.	9.3	A. St. lowered and
8 43.5	2,627	562.9	12.1	0.46	58	6.171	N. 54° W.	10.7	thickened dur-
8 45.0	2,849	548.0	11.0	0.50	61	6.060	N. 47° W.	13.3	ing ascension.
8 45.6	3,000	......	10.2	......	63	5.952	N. 45° W.	12.5	
8 48.4	3,500	......	7.7	......	71	5.721	N. 31° W.	9.4	
8 49.4	3,659	497.0	6.9	0.51	73	5.587	N. 28° W.	9.1	
8 50.9	3,903	482.3	5.5	0.57	71	4.961	N. 33° W.	10.1	
8 51.3	4,000	......	5.1	......	72	4.900	N. 37° W.	10.3	
8 53.4	4,364	455.9	3.4	0.46	76	4.622	N. 62° W.	10.7	Thin clouds
8 54.2	4,500	......	3.3	......	78	4.713	N. 69° W.	10.7	passing under
8 54.5	4,568	444.5	3.3	0.05	79	4.773	N. 71° W.	10.7	balloon.
8 55.5	4,717	436.4	2.6	0.47	80	4.613	N. 73° W.	10.5	Clock stopped.
8 56.8	5,000	......	......	......	......	......	N. 66° W.	10.1	
9 02.4	6,000	......	......	......	......	......	N. 74° W.	13.9	
9 08.3	7,000	......	......	......	......	......	N. 74° W.	21.1	
9 11.0	......	......	......	......	......	......	......	......	Balloon disappeared in clouds.

JULY 18, 1914 (Series No. 10).

Time.	Alti-tude.	Pres-sure.	Tem-pera-ture.	Δt 100 m.	Rel-ative.	Abso-lute.	Direc-tion.	Ve-locity.	Remarks.
A. M.									
11 00.0	312	739.5	21.1	......	62	11.314	S. 19° E.	1.6	9/10 A. St., w.
11 01.2	496	723.8	20.8	0.16	66	11.836	S. 16° E.	2.0	1/10 St. Cu., nnw.
11 03.0	786	609.7	17.3	1.13	67	9.780	S. 13° W.	5.7	
11 04.2	974	684.3	16.5	0.43	68	9.463	S. 6° W.	4.3	
11 04.4	1,000	......	16.8	......	67	9.493	S. 5° W.	4.1	
11 04.9	1,059	677.5	17.6	−1.29	65	9.659	S. 20° W.	3.7	
11 06.4	1,230	664.0	17.3	0.18	59	8.612	S. 58° W.	5.9	
11 08.3	1,500	......	16.1	......	56	7.608	S. 69° W.	7.1	
11 09.4	1,693	628.7	15.2	0.45	54	6.948	S. 71° W.	6.4	
11 12.0	2,000	......	13.1	......	53	6.000	S. 71° W.	5.3	
11 12.8	2,169	594.1	12.0	0.67	52	5.498	S. 71° W.	5.3	
11 15.3	2,500	......	9.5	......	53	4.791	N. 74° W.	3.9	
11 16.1	2,614	563.1	8.6	0.76	53	4.524	N. 63° W.	3.8	
11 17.5	2,828	548.7	8.0	0.28	55	4.518	N. 42° W.	4.3	Clouds becoming
11 18.9	3,000	......	7.0	......	57	4.391	N. 18° W.	5.7	heavier and
11 22.2	3,500	......	4.1	......	61	3.887	N. 21° W.	4.6	lower.
11 22.6	3,602	499.2	3.5	0.58	62	3.796	N. 24° W.	4.5	
11 25.4	4,000	......	0.8	......	63	3.217	N. 72° W.	7.7	
11 27.0	4,260	460.0	− 1.0	0.69	64	2.860	......	......	Balloon disap-
11 28.5	4,506	445.9	− 2.3	0.53	67	2.702	......	......	peared in
11 31.7	5,000	......	− 3.8	......	71	2.539	......	......	clouds.
11 32.1	5,044	416.8	− 3.9	0.30	71	2.518	......	......	
11 32.6	5,133	412.1	− 3.4	−0.57	71	2.623	......	......	
11 34.5	5,459	395.4	− 5.0	0.38	70	2.271	......	......	
11 37.1	6,000	......	− 8.5	......	70	1.705	......	......	
11 37.4	6,057	366.2	− 8.8	0.64	70	1.665	......	......	
11 40.4	6,691	337.3	−10.5	0.27	71	1.466	......	......	
11 41.6	7,000	......	−11.6	......	71	1.333	......	......	
11 43.8	7,574	300.8	−13.5	0.34	71	1.126	......	......	
11 45.3	8,000	......	−15.2	......	70	0.960	......	......	
11 46.3	8,255	275.1	−16.3	0.41	70	0.874	......	......	
11 49.0	9,000	......	−20.2	......	69	0.603	......	......	
11 50.0	9,370	237.1	−22.2	0.53	69	0.499	......	......	
11 52.0	10,000	......	−26.7	......	69	0.324	......	......	
11 52.3	10,099	214.5	−27.4	0.71	69	0.302	......	......	
11 53.2	10,411	205.4	−30.2	0.90	69	0.232	......	......	

JULY 18, 1914 (Series No. 11).

Time.	Alti-tude.	Pres-sure.	Tem-pera-ture.	Δt 100 m.	Rel-ative.	Abso-lute.	Direc-tion.	Ve-locity.	Remarks.
P. M.									
1 32.0	312	738.8	25.1	......	57	13.066	S. 1° W.	3.5	10/10 A. St., w.
1 32.9	486	724.2	22.2	1.67	59	11.471	S. 1° W.	3.5	
1 33.1	500	......	22.0	......	59	11.340	S. 5° W.	4.0	
1 34.7	791	699.0	19.3	0.95	64	10.515	S. 20° W.	4.9	
1 35.3	854	693.8	19.7	−0.63	61	10.260	S. 40° W.	5.3	
1 36.4	1,000	......	18.9	......	60	9.629	S. 63° W.	4.7	
1 38.5	1,385	651.9	16.9	0.53	56	7.982	S. 62° W.	4.8	
1 39.6	1,500	......	16.4	......	55	7.608	S. 56° W.	5.0	
1 42.0	1,886	614.4	14.9	0.40	51	6.444	S. 44° W.	3.1	
1 42.7	2,000	......	14.2	......	52	6.296	S. 44° W.	2.7	
1 45.8	2,500	......	11.2	......	58	5.834	S. 59° W.	1.7	
1 47.3	2,707	557.1	9.9	0.61	60	5.563	S. 72° W.	1.3	
1 48.7	3,000	......	8.0	......	63	5.175	S. 82° W.	1.1	
1 50.2	3,247	521.9	6.4	0.65	66	4.890	S. 78° W.	2.8	
1 51.5	3,500	......	4.0	......	69	4.368	S. 75° W.	4.2	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 18, 1914 (Series No. 11)—Continued.

Time.	Alti-tude.	Pres-sure.	Tem-pera-ture.	Δt 100 m.	Humidity.		Wind.		Remarks.
					Rel-ative.	Abso-lute.	Direc-tion.	Ve-locity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
1 53.0	3,765	489.5	1.6	0.93	73	3.935	S. 80° W.	5.9	Balloon entered
1 54.1	4,000	......	1.2	......	78	4.093	......	......	cloud layer; ap-
1 55.1	4,183	464.7	0.8	0.19	82	4.187	......	......	parently struck
1 56.4	4,443	450.0	− 0.5	0.50	84	3.904	......	......	very high
1 56.7	4,500	......	− 0.2	......	81	3.855	......	......	wind.
1 57.3	4,619	440.2	0.3	−0.45	76	3.751	......	......	
1 59.1	5,000	......	− 2.1	......	70	2.869	......	......	
1 59.6	5,118	413.4	− 2.9	0.64	68	2.614	......	......	
2 00.3	5,265	406.1	− 2.9	0.00	66	2.537	......	......	
2 02.2	5,628	387.8	− 4.8	0.52	66	2.177	......	......	
2 03.8	6,000	......	− 7.5	......	68	1.796	......	......	
2 05.2	6,364	352.9	−10.1	0.72	69	1.474	......	......	
2 07.1	6,791	333.7	−10.7	0.14	72	1.461	......	......	
2 08.0	7,000	......	−12.1	......	72	1.292	......	......	
2 10.1	7,542	302.8	−15.9	0.69	73	0.944	......	......	
2 12.0	8,000	......	−18.7	......	74	0.740	......	......	
2 13.1	8,375	270.8	−21.0	0.61	74	0.599	......	......	
2 15.6	9,000	......	−25.9	......	73	0.372	......	......	
2 17.2	9,486	232.9	−29.8	0.79	73	0.255	......	......	
2 19.0	10,000	......	−33.0	......	73	0.184	......	......	
2 21.2	10,649	197.8	−37.1	0.63	73	0.120	......	......	
2 22.2	11,000	......	−40.1	......	72	0.085	......	......	
2 25.1	11,894	165.0	−47.7	0.85	70	0.036	......	......	
2 25.4	12,000	......	−48.5	......	70	0.032	......	......	
2 28.1	13,000	......	−56.3	......	68	0.012	......	......	
2 29.1	13,295	133.6	−58.6	0.78	68	0.009	......	......	
2 29.7	13,488	130.0	−58.1	−0.26	68	0.010	......	......	
2 30.6	13,957	120.6	−60.2	0.45	67	0.007	......	......	
2 31.1	14,000	......	−60.1	......	67	0.007	......	......	
2 31.8	14,208	116.2	−59.5	−0.28	67	0.007	......	......	
2 32.6	14,488	111.3	−60.7	0.43	67	0.006	......	......	
2 33.3	14,660	108.1	−60.3	−0.23	67	0.006	......	......	
2 34.9	15,000	......	−61.3	......	67	0.005	......	......	
2 37.0	15,565	93.9	−63.1	0.28	67	0.004	......	......	
2 39.0	16,000	......	−61.9	......	67	0.005	......	......	
2 40.3	16,285	84.0	−59.5	−0.50	67	0.007	......	......	
2 44.0	16,874	76.6	−56.3	−0.54	67	0.011	......	......	
2 44.3	17,000	......	−56.3	......	67	0.011	......	......	
2 46.6	17,697	67.4	−56.2	−0.01	67	0.012	......	......	
2 48.5	18,000	......	−53.8	......	67	0.017	......	......	
2 51.1	18,535	59.4	−49.6	−0.79	67	0.027	......	......	
2 53.5	19,000	......	−47.6	......	67	0.034	......	......	
2 54.6	19,189	53.8	−46.7	−0.44	67	0.038	......	......	
2 58.0	19,903	48.3	−46.3	−0.06	67	0.040	......	......	

JULY 18, 1914 (Series No. 12).

Time.	Alti-tude.	Pres-sure.	Tem-pera-ture.	Δt 100 m.	Rel-ative.	Abso-lute.	Direc-tion.	Ve-locity.	Remarks.
P. M.									
4 00.0	312	736.0	24.4	......	57	12.561	S. 40° W.	5.2	8/10 A. St., nw.
4 01.2	500	......	21.5	......	60	11.205	S. 40° W.	5.6	1/10 A. Cu., nw.
4 01.8	578	713.7	20.3	1.54	61	10.626	S. 40° W.	6.1	
4 03.9	912	686.5	17.6	0.81	68	10.105	S. 59° W.	9.0	
4 04.3	1,000	......	17.9	......	64	9.681	S. 60° W.	8.7	
4 05.0	1,080	673.0	18.1	−0.30	61	9.338	S. 60° W.	7.5	
4 07.0	1,500	......	16.5	......	61	8.489	S. 55° W.	6.5	
4 09.6	2,000	......	14.7	......	61	7.614	S. 40° W.	5.6	
4 09.7	2,011	602.9	14.7	0.37	61	7.614	S. 41° W.	5.5	
4 12.6	2,500	......	12.2	......	58	6.209	S. 18° W.	2.1	
4 12.8	2,576	563.6	11.8	0.51	57	5.953	S. 14° W.	1.8	Clouds breaking
4 15.6	3,000	......	8.7	......	64	5.498	S. 26° W.	1.9	in northeast,
4 16.9	3,225	521.3	7.0	0.74	67	5.161	S. 21° W.	1.2	exposing Ci. St.
4 18.5	3,500	......	5.2	......	73	5.001	S. 65° W.	3.3	
4 20.5	3,850	482.9	3.0	0.64	80	4.738	N. 49° W.	5.4	
4 21.4	4,000	......	2.8	......	80	4.675	N. 35° W.	6.6	
4 22.3	4,150	465.4	2.5	0.17	79	4.525	N. 42° W.	8.3	
4 24.3	4,500	......	0.7	......	73	3.703	N. 40° W.	9.8	
4 26.8	4,915	423.0	− 1.4	0.51	66	2.858	N. 18° W.	9.8	
4 27.3	5,000	......	− 1.4	......	63	2.728	N. 20° W.	9.1	
4 28.9	5,272	404.3	− 1.4	0.00	53	2.295	N. 42° W.	6.1	
4 33.1	6,000	......	− 5.4	......	37	1.161	N. 47° W.	10.7	
4 33.3	6,069	365.5	− 5.8	0.55	36	1.094	N. 48° W.	11.2	
4 34.0	6,211	359.2	− 6.9	0.77	36	0.999	N. 50° W.	12.8	
4 38.7	7,000	......	−10.1	......	30	0.641	N. 68° W.	19.8	
4 38.9	7,043	322.6	−10.2	0.40	30	0.635	N. 70° W.	20.2	
4 41.2	7,456	305.9	−13.7	0.85	36	0.561	N. 75° W.	23.0	
4 42.6	7,770	293.8	−14.0	0.10	39	0.592	N. 83° W.	25.2	
4 44.2	8,000	......	−15.5	......	41	0.548	W.	26.2	
4 46.2	8,368	271.1	−18.0	0.67	45	0.486	S. 85° W.	28.8	2/10 Ci. St., nw.
4 49.5	9,000	......	−22.2	......	46	0.332	S. 81° W.	26.3	3/10 A. St., nw.
4 50.6	9,240	241.2	−23.3	0.61	46	0.301	S. 85° W.	27.8	2/10 A. Cu., nw.
4 54.1	9,970	218.6	−28.6	0.73	48	0.187	N. 89° W.	33.4	
4 54.6	10,000	......	−28.8	......	48	0.183	N. 89° W.	36.3	
4 56.9	10,460	204.0	−31.9	0.67	46	0.130	......	......	Balloon entered
5 00.0	11,000	......	−35.9	......	45	0.084	......	......	cloud layer.
5 00.9	11,165	184.8	−37.1	0.75	45	0.074	......	......	1/10 Ci. St., nw.
5 03.3	11,741	170.0	−41.0	0.68	43	0.046	......	......	2/10 A. St., nw.
5 03.8	11,857	167.2	−43.1	1.81	43	0.037	......	......	4/10 A. Cu., nw.
5 04.9	12,000	......	−44.0	......	43	0.033	......	......	
5 07.4	12,683	148.2	−48.5	0.65	42	0.019	......	......	
5 09.3	13,000	......	−51.9	......	41	0.012	......	......	
5 10.2	13,291	135.1	−55.0	1.07	40	0.008	......	......	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr*—Continued.

JULY 18, 1914 (Series No. 12)—Continued.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*° C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
5 13.1	13,891	123.3	−60.3	0.88	40	0.004			
5 13.5	14,000		−60.5		40	0.004			
5 15.5	14,595	110.4	−61.8	0.21	40	0.003			
5 17.1	15,000		−64.0		40	0.002			
5 19.0	15,565	94.8	**−67.0**	0.54	40	0.001			
5 20.2	16,000		−64.9		40	0.002			
5 21.4	16,407	83.1	−63.0	−0.48	40	0.002			
5 23.0	17,000		−61.7		40	0.003			
5 24.5	17,624	68.7	−60.3	−0.22	41	0.004			
5 25.5	18,000		−60.3		41	0.004			
5 26.2	18,327	61.4	−60.3	0.00	41	0.004			
5 28.0	19,000		−57.7		41	0.006			
5 30.2	19,817	48.7	−54.6	−0.38	41	0.009			
5 30.4	20,000		−54.7		41	0.009			
5 31.3	20,422	44.5	−54.9	0.05	41	0.009			
5 32.5	21,000		−53.5		41	0.010			
5 34.3	22,000		−51.1		41	0.014			
5 35.9	**22,930**	30.3	−49.0	−0.24	41	0.018			

JULY 19, 1914.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
P. M.									
4 03.0	312	736.0	30.1		44	13.288	S. 43° W.	3.8	4/10 Cu., w.
4 04.0	500		27.9		46	12.321	S. 48° W.	4.2	
4 04.4	590	713.2	26.8	1.19	47	11.846	S. 52° W.	4.6	
4 06.3	920	686.7	24.9	0.58	45	10.200	S. 55° W.	4.3	
4 07.0	1,000		24.0		46	9.910	S. 58° W.	4.2	
4 08.8	1,311	656.5	20.7	1.07	52	9.271	S. 69° W.	4.1	Obscured by Cu. at intervals after 4:09 p. m.
4 10.2	1,500		19.4		55	9.090	S. 77° W.	4.4	
4 12.7	1,895	613.2	16.8	0.67	62	8.784	N. 44° W.	2.6	
4 13.3	2,000		15.9		64	8.591	N. 2° W.	1.9	
4 15.3	2,427	575.7	12.3	0.85	71	7.648	N. 58° E.	2.7	
4 15.7	2,500		12.0		70	7.402	N. 49° E.	2.9	
4 16.4	2,701	557.0	11.2	0.40	66	6.639	N. 33° E.	3.2	
4 18.1	3,000		9.7		64	5.859	N. 4° W.	2.3	
4 20.8	3,500		7.3		62	4.869	N. 15° W.	4.1	
4 21.2	3,603	499.4	6.8	0.49	61	4.638	N. 19° W.	4.2	
4 23.5	4,000		5.3		48	3.310	N. 62° W.	2.7	
4 24.7	4,235	462.4	4.4	0.38	41	2.665	N. 65° W.	2.8	
4 26.2	4,500		3.7		37	2.296	N. 73° W.	4.7	
4 27.9	4,768	432.9	2.9	0.28	33	1.941	N. 71° W.	6.4	
4 29.0	5,000		1.7		31	1.683	N. 64° W.	7.0	
4 31.4	5,440	398.3	− 0.5	0.51	27	1.255	N. 44° W.	12.1	
4 33.6	5,891	376.4	− 3.5	0.67	26	0.953	N. 44° W.	11.5	
4 34.3	6,007	371.0	− 3.1	−0.34	25	0.946	N. 46° W.	11.2	
4 35.3	6,163	363.8	− 4.6	0.96	24	0.804	N. 49° W.	11.1	
4 36.9	6,442	351.0	− 6.8	0.79	23	0.644	N. 54° W.	11.4	
4 38.3	6,774	336.5	− 6.8	0.00	22	0.616	N. 54° W.	12.4	
4 39.1	6,939	329.3	− 8.6	1.09	22	0.532	N. 54° W.	13.0	
4 39.8	7,000		− 8.8		22	0.523	N. 56° W.	13.4	
4 41.0	7,288	314.9	− 9.9	0.37	22	0.478	N. 59° W.	14.7	
4 43.0	7,600	302.4	−11.6	0.54	21	0.394	N. 62° W.	15.8	
4 45.0	8,000		−15.0		20	0.279	N. 62° W.	15.7	
4 46.1	8,214	279.0	−16.8	0.85	20	0.239	N. 59° W.	16.4	
4 49.5	8,923	253.9	−20.4	0.51	20	0.172	N. 62° W.	19.3	
4 50.1	9,000		−20.7		20	0.167	N. 66° W.	21.1	
4 54.0	9,808	225.5	−24.4	0.45	19	0.112	N. 74° W.	25.8	
4 54.9	10,000		−25.4		19	0.102	N. 69° W.	29.4	2/10 Cu., w.
4 59.2	10,996	191.4	−30.5	0.51	18	0.059	N. 69° W.	33.5	
5 03.8	12,000		−39.6		17	0.021			
5 04.3	12,085	164.4	−40.4	0.91	17	0.019			
5 05.9	12,539	153.7	−44.7	0.95	17	0.012			
5 07.4	12,676	150.3	−46.4	1.24	17	0.010			
5 07.9	13,000		−48.4		17	0.008			
5 10.0	13,548	132.3	−51.7	0.61	16	0.005			
5 11.5	14,000		−52.6		16	0.004			
5 12.9	14,514	114.3	−53.5	0.19	16	0.004			
5 14.9	15,000		−54.5		15	0.003			
5 16.9	15,643	96.3	−55.8	0.20	14	0.003			
5 17.8	16,000		−56.1		14	0.003			
5 20.3	17,000		−56.9		14	0.002			
5 20.8	17,117	76.8	**−57.0**	0.08	14	0.002			
5 22.4	17,943	67.7	−56.3	−0.08	15	0.003			
5 22.8	18,000		−56.3		15	0.003			
5 24.1	18,653	60.7	−56.8	0.07	15	0.002			
5 25.0	19,000		−55.8		15	0.003			
5 26.5	19,940	49.8	−52.9	−0.30	16	0.004			
5 27.1	20,000		−52.9		16	0.004			
5 28.0	20,457	46.1	−52.7	−0.04	16	0.004			
5 29.5	21,000		−49.9		16	0.006			
5 31.5	21,546	39.2	−47.2	−0.51	16	0.009			
5 32.0	22,000		−46.3		16	0.009			
5 34.2	23,000		−44.3		16	0.010			
5 35.9	23,760	28.2	−42.8	−0.20	16	0.014			
5 36.7	24,000		−41.9		16	0.016			
5 39.3	25,000		−38.1		17	0.025			
5 39.9	25,140	23.1	−37.5	−0.38	17	0.027			
5 42.1	26,000		−36.4		16	0.028			
5 42.6	26,338	19.4	−35.9	−0.13	16	0.030			
5 44.8	27,000		−36.8		16	0.027			
5 46.8	**27,782**	15.8	−37.9	0.14	16	0.024			

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr*—Continued.

JULY 20, 1914.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
H. m.	*M.*	*Mm.*	*° C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
4 01.0	312	733.0	24.7		66	14.793	S. 55° E.	2.2	7/10 A.St., w.
4 01.9	472	719.6	21.8	1.81	68	12.920	S. 47° E.	4.2	3/10 St.Cu., w.
4 02.3	500		21.5		69	12.886	S. 38° E.	6.2	
4 03.2	635	706.2	19.8	1.23	72	12.182	S. 16° E.	8.6	
4 04.7	859	687.9	18.7	0.49	72	11.419	S. 7° W.	10.7	
4 05.7	1,000		17.6		73	10.848	S. 18° W.	11.3	
4 06.7	1,108	668.0	16.7	0.80	74	10.421	S. 27° W.	11.7	
4 09.0	1,450	641.6	16.5	0.06	68	9.463	S. 41° W.	7.6	3/10 A.St., w.
4 09.2	1,500		16.1		69	9.374	S. 41° W.	7.5	7/10 St.Cu., w.
4 12.2	2,000		12.6		75	8.230	S. 46° W.	6.8	
4 12.4	2,029	599.0	12.4	0.71	75	8.129	S. 46° W.	6.9	
4 14.9	2,500		9.2		86	7.627	S. 48° W.	6.1	
4 16.3	2,778	547.2	7.4	0.67	92	7.272	S. 52° W.	6.8	Light sprinkle.
4 17.7	3,000		6.1		95	6.903	S. 56° W.	6.8	
4 19.5	3,327	511.9	4.1	0.60	100	6.372	S. 58° W.	5.9	
4 20.7	3,500		3.4		97	5.900	S. 55° W.	5.2	
4 22.0	3,686	480.5	2.7	0.39	93	5.400	S. 58° W.	4.4	Balloon in base of cloud layer.
4 23.7	4,000		0.8		94	4.800	S. 86° W.	4.0	
4 24.7	4,144	462.4	− 0.1	0.61	94	4.508	W.	4.2	
4 26.7	4,500		− 1.3		97	4.233	S. 81° W.	5.1	
4 29.0	4,889	421.2	− 2.7	0.35	100	3.906	S. 88° W.	5.5	2/10 A.St., w.
4 29.6	5,000		− 3.2		99	3.716			8/10 St.Cu., w.
4 34.4	5,960	367.8	− 7.3	0.43	90	2.416			
4 34.7	6,000		− 7.5		90	2.377			
4 39.3	7,000		−11.7		91	1.693			
4 39.3	7,015	320.8	−11.7	0.42	91	1.693			
4 43.4	8,000		−17.1		87	1.015			
4 44.2	8,216	274.0	−18.3	0.55	86	0.902			
4 47.3	9,000		−22.5		74	0.520			
4 49.5	9,756	222.6	−26.4	0.53	63	0.306			
4 50.8	10,000		−28.2		63	0.255			
4 54.1	11,000		−35.6		62	0.119			
4 54.3	11,060	185.2	−36.1	0.74	62	0.113			
4 55.8	11,425	176.0	−36.9	0.22	62	0.104			
4 57.2	12,000		−39.9		59	0.071			
4 59.5	12,770	145.2	−44.0	0.53	56	0.043			
5 00.1	13,000		−45.0		56	0.038			
5 02.8	14,000		−49.3		54	0.023			
5 03.9	14,392	114.1	−51.0	0.43	54	0.018			Clock stopped, but ran again later.
	15,000		−52.9		54	0.015			
	15,146	101.8	**−53.4**	0.32	54	0.014			
	22,217	35.6	−37.2	−0.55	53	0.086			
	22,792	32.9	−36.6	−0.10	53	0.092			
	23,000		−36.1		53	0.096			
	23,886	28.1	−34.1	−0.23	52	0.118			
	24,000		−34.0		52	0.119			
	24,705	25.0	−33.7	−0.05	52	0.122			
	25,000		−33.3		51	0.125			
	25,481	22.2	−32.3	−0.32	50	0.136			
	25,000		−34.5		49	0.106			
	24,256	26.5	−38.0	0.06	48	0.071			
	24,000		−37.8		48	0.073			
	23,485	29.7	−37.5	−0.16	48	0.075			
	23,000		−38.3		48	0.069			
	22,000		−39.9		49	0.059			
	21,641	38.8	−40.4	0.06	49	0.056			
	21,000		−40.0		50	0.060			
	20,589	45.1	−39.8	−1.18	50	0.061			
	20,334	46.7	−42.8	−0.38	51	0.045			
	20,000		−44.1		51	0.038			
	19,757	51.0	−45.0	−0.06	52	0.035			
	19,000		−45.5		52	0.033			
	18,771	59.0	−45.6	−0.31	53	0.033			
	18,000		−48.0		53	0.026			
	17,113	75.6	−50.7	−0.14	54	0.019			
	17,000		−50.9		54	0.018			
	16,000		−52.3		54	0.016			

JULY 21, 1914.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Humidity. Relative.	Humidity. Absolute.	Wind. Direction.	Wind. Velocity.	Remarks.
P. M.									
4 00.0	312	730.0	33.2		46	16.398	S. 40° E.	7.0	Cloudless.
4 01.1	500		31.1		48	15.299	S. 33° E.	6.9	
4 01.8	704	698.5	28.8	1.12	51	14.350	S. 24° E.	8.6	
4 04.2	1,000		26.5		55	13.633	S. 6° W.	12.3	
4 05.0	1,195	660.5	25.0	0.77	58	13.221	S. 10° W.	12.9	
4 07.2	1,500		22.6		66	13.129	S. 32° W.	11.3	
4 08.4	1,680	624.6	21.2	0.78	70	12.848	S. 47° W.	10.6	
4 10.2	2,000		18.9		74	11.876	S. 62° W.	11.8	
4 11.7	2,280	582.4	16.9	0.72	78	11.117	S. 71° W.	10.9	
4 12.9	2,500		16.8		63	8.926	S. 77° W.	8.0	
4 13.0	2,529	565.6	16.8	0.04	61	8.642	S. 77° W.	7.8	
4 14.5	2,859	543.9	15.2	0.48	46	5.919	S. 71° W.	4.3	
4 15.5	3,000		14.3		42	5.116	S. 68° W.	3.5	
4 17.8	3,500		11.2		29	2.917	S. 71° W.	4.7	
4 17.9	3,521	502.7	11.0	0.63	28	2.782	S. 72° W.	4.7	
4 20.3	4,000		7.9		26	2.122	S. 89° W.	6.7	
4 21.7	4,255	460.1	6.2	0.65	22	1.609	N. 89° W.	8.3	
4 23.0	4,500		4.8		22	1.468	S. 84° W.	9.0	
4 25.2	4,910	424.4	2.4	0.58	22	1.252	N. 1° W.	6.7	
4 25.6	5,000		2.1		22	1.227	N. 7° W.	6.2	
4 28.1	5,448	397.1	0.4	0.37	21	1.043	N. 35° W.	2.6	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 21, 1914—Continued.

Time.	Altitude.	Pressure.	Temperature.	Δt / 100 m.	Humidity.		Wind.		Remarks.
					Relative.	Absolute.	Direction.	Velocity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
4 30.9	6,000	....	− 3.1	....	20	0.757	N.75° W.	1.2	
4 33.9	6,580	344.6	− 6.9	0.64	19	0.527	N.58° W.	3.4	
4 35.8	6,934	328.8	− 8.1	0.34	18	0.453	N.78° W.	4.2	
4 36.1	7,000	....	− 8.5	....	18	0.438	N.79° W.	4.0	
4 41.0	7,968	287.8	−14.2	0.59	16	0.239	N.55° W.	8.2	
4 41.2	8,000	....	−14.4	....	16	0.235	N.58° W.	8.0	
4 45.0	8,788	257.9	−20.2	0.73	16	0.140	S. 85° W.	6.9	
4 46.0	9,000	....	−20.3	....	16	0.139	S. 86° W.	7.4	
4 48.9	9,646	229.8	−25.4	0.61	16	0.086	N.83° W.	8.0	
4 50.6	10,000	....	−27.8	....	15	0.063	N.72° W.	10.9	
4 51.2	10,110	215.7	−28.6	0.69	14	0.054	N.70° W.	11.5	
4 54.5	11,000	....	−33.7	....	14	0.033	N.68° W.	17.7	
4 55.0	11,104	187.8	−34.3	0.57	14	0.031	N.68° W.	19.0	
4 56.0	11,161	186.2	−34.9	1.05	14	0.029	N.70° W.	22.6	
4 59.0	12,000	....	−38.3	....	14	0.020	N.64° W.	24.5	
4 59.5	12,110	162.8	−38.7	0.40	14	0.019	N.64° W.	23.9	
5 03.0	13,000	....	−45.2	....	14	0.009	N.65° W.	22.0	
5 03.4	13,110	141.0	−46.0	0.73	14	0.009	N.65° W.	22.5	
5 06.5	14,000	....	−49.4	....	13	0.005	N.59° W.	16.7	
5 07.2	14,303	118.1	−50.5	0.38	13	0.005	N.58° W.	14.1	
5 09.7	15,000	....	−53.9	....	13	0.003	N.66° W.	16.1	
5 10.5	15,340	101.1	−55.6	0.49	13	0.002	N.69° W.	17.4	
5 11.5	15,750	95.0	−55.1	−0.12	13	0.003	N.75° W.	17.8	

TABLE 3.—*Results of sounding balloon ascensions, Fort Omaha, Nebr.*—Continued.

JULY 21, 1914—Continued.

Time.	Altitude.	Pressure.	Temperature.	Δt / 100 m.	Humidity.		Wind.		Remarks.
					Relative.	Absolute.	Direction.	Velocity.	
H. m.	*M.*	*Mm.*	*°C.*		*Per cent.*	*G./cu. m.*		*M.p.s.*	
P. M.									
5 12.4	16,000	....	−56.1	....	13	0.002	N.84° W.	17.8	
5 13.8	16,636	82.8	−58.6	0.40	13	0.002	N.64° W.	13.8	Cloudless.
5 15.0	17,000	....	−56.9	....	13	0.002	N.27° W.	7.8	
5 16.0	**17,402**	73.5	−55.0	−0.47	13	0.003	....	....	Balloon burst.

JULY 22, 1914.

Time.	Altitude.	Pressure.	Temperature.	Δt / 100 m.	Relative.	Absolute.	Direction.	Velocity.	Remarks.
P. M.									
4 00.0	312	733.3	33.8	....	45	16.557	N.78° W.	3.4	6/10 St.Cu.,sw.
4 02.1	496	718.3	30.9	1.58	46	14.505	N.79° W.	4.7	
4 04.2	816	692.8	27.9	0.94	54	14.463	S.70° W.	4.4	
4 04.8	1,000	....	26.0	....	58	13.983	S.53° W.	4.2	
4 07.1	1,500	....	20.9	....	70	12.626	S.47° W.	6.5	
4 07.2	1,522	638.9	20.7	1.02	71	12.659	S.47° W.	6.7	
4 09.3	1,850	615.0	17.6	0.95	74	10.996	S.35° W.	12.3	
4 10.0	2,000	....	17.8	....	64	9.624	S.36° W.	14.4	
4 10.4	2,035	601.7	17.8	−0.11	63	9.474	S.37° W.	15.7	
4 11.6	.2,226	588.3	17.3	0.26	57	8.320	S.38° W.	17.5	
4 12.1	**2,464**	571.9	**16.0**	0.55	55	7.427	....	....	1 balloon burst.

TABLE 4.—*Absolute humidity (grams per cubic meter) at varying levels on different dates, Fort Omaha, Nebr., 1914.**

Date.	Altitude (meters).																	
	312	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000	9,000	10,000	11,000	12,000
1914.	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*
July 9	14.955	12.790	10.251	9.547	3.323	2.723	2.451	2.421	2.066	1.662	1.270	0.685	0.373	0.191	0.085	0.036	0.015	0.006
July 11	20.212	16.398	13.155	11.572	8.123	5.613	3.858	2.713	1.976	1.310	0.812	0.410	0.203	0.087	0.068	0.024	0.009	0.003
July 14	15.278	14.196	11.560	9.252	5.782	3.271	2.087	1.237	0.939	0.654	0.483	0.266	0.107	0.077	0.044	0.024	0.011	0.004
July 15	19.064	16.400	12.767	11.148	10.426	8.474	6.264	4.739	3.745	3.165	2.749	2.366	1.292	0.710	0.429	0.244	0.141	
July 17, No. 2	6.651	6.797	5.229	3.918	2.925	2.491	2.134	1.781	1.478	1.140	0.833	0.448	0.289	0.131	0.073	0.034	0.013	0.005
July 18, No. 12	12.561	11.205	9.681	8.489	7.614	6.209	5.498	5.001	4.675	3.703	2.728	1.161	0.641	0.548	0.333	0.183	0.084	0.033
July 19	13.288	12.321	9.910	9.090	8.591	7.402	5.859	4.869	3.310	2.296	1.683	0.946	0.523	0.279	0.167	0.102	0.059	0.021
July 20	14.793	12.886	10.848	9.374	8.230	7.627	6.903	5.900	4.800	4.233	3.716	2.377	1.693	1.015	0.520	0.255	0.119	0.071
July 21	16,398	15.299	13.633	13.129	11.876	8.926	5.116	2.917	2.122	1.468	1.227	0.757	0.438	0.235	0.139	0.063	0.033	0.020
Means	**14.800**	**13.144**	**10.782**	**9.502**	**7.432**	**5.860**	**4.463**	**3.509**	**2.790**	**2.181**	**1.722**	**1.046**	**0.618**	**0.364**	**0.206**	**0.107**	**0.060**	**0.020**

Date.	Altitude (meters).																		
	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000	23,000	24,000	25,000	26,000	27,000	28,000	29,000	30,000	31,000
1914.	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*	*G./ cu. m.*
July 9	0.005	0.005	0.003	0.002	0.004	0.002	0.002	0.003	0.004	0.006	0.008	0.010	0.013	0.018	0.028	0.070	0.093	0.104	0.116
July 11	0.001	0.001	0.001	0.001															
July 14	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003										
July 15																			
July 17, No. 2	0.003	0.002	0.001	0.002	0.003	0.004	0.006	0.011											
July 18, No. 12	0.012	0.004	0.002	0.002	0.003	0.004	0.006	0.009	0.010	0.014									
July 19	0.008	0.004	0.003	0.003	0.002	0.003	0.003	0.004	0.006	0.009	0.010	0.016	0.025	0.028	0.027				
July 20	0.038	0.023	0.015	0.016	0.018	0.026	0.033	0.038	0.060	0.059	0.069	0.073	0.106						
July 21	0.009	0.005	0.003	0.002	0.002														
Means	**0.010**	**0.006**	**0.004**	**0.004**	**0.005**	**0.007**	**0.009**	**0.011**	**0.017**	**0.022**	**0.029**	**0.033**	**0.048**	**0.023**	**0.028**	**(0.070)**	**(0.093)**	**(0.104)**	**(0.116)**

* These ascensions were made in the afternoons, beginning between 3 and 4.15 p. m.

TABLE 5.—*Observed values of absolute humidity (grams per cubic meter) at various levels, during the diurnal series at Fort Omaha, Nebr., July 17–18, 1914.*

Number and time of ascension.	Altitude (meters).													
	312	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000	7,000	8,000
July 17–18, 1914.	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*
1, 12:30.5 p. m.	6.607	5.829	4.693	3.825	3.178	2.636	2.402	1.976	1.459	1.115	0.880	0.499	0.326	0.188
2, 3:00 p. m.	6.651	6.797	5.229	3.918	2.925	2.491	2.134	1.781	1.478	1.140	0.833	0.448	0.289	0.131
3, 5:31 p. m.	8.259	7.767	6.002	5.170	4.472	3.523	2.183	1.750	1.300	0.984	0.702	0.373	0.189	0.124
4, 8:10 p. m.	9.369	9.720	7.346	6.051	4.575	4.042	3.245	2.015	1.595	1.359	0.916	0.498	0.297	0.147
5, 10:34 p. m.	10.844													
6, 1:07 a. m.	10.998	10.515	8.585	6.466	4.844	4.011	3.620	3.257	2.843	2.287	1.525	0.737	0.381	0.272
7, 3:47 a. m.	10.500	11.008	8.838	6.701	5.570	4.584	4.272	3.970	3.367	2.804	1.903	0.888	0.574	0.458
8, 6:05 a. m.	10.844													
9, 8:30 a. m.	11.367	10.716	9.363	7.501	6.459	6.294	5.952	5.721	4.900	4.713				
10, 11:00 a. m.	11.314	11.836	9.493	7.608	6.000	4.791	4.391	3.887	3.217	2.702	2.539	1.705	1.333	0.960
11, 1:32 p. m.	13.066	11.840	9.629	7.608	6.296	5.834	5.175	4.368	4.093	3.855	2.869	1.796	1.292	0.740
12, 4:00 p. m.	12.561	11.205	9.681	8.489	7.614	6.209	5.498	5.001	4.675	3.703	2.728	1.161	0.641	0.548

Number and time of ascension.	Altitude (meters).													
	9,000	10,000	11,000	12,000	13,000	14,000	15,000	16,000	17,000	18,000	19,000	20,000	21,000	22,000
July 17–18, 1914.	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*	*G./cu. m.*
1, 12:30.5 p. m.	0.131	0.064	0.029	0.016	0.010	0.007	0.005	0.004	0.005	0.008	0.011	0.013	0.018	0.026
2, 3:00 p. m.	0.073	0.034	0.013	0.005	0.003	0.002	0.001	0.002	0.003	0.004	0.006	0.011		
3, 5:31 p. m.	0.055	0.017	0.006	0.004	0.002	0.002	0.002	0.003	0.004	0.005	0.006	0.006	0.008	0.014
4, 8:10 p. m.	0.069	0.031	0.013	0.007	0.005									
5, 10:34 p. m.														
6, 1:07 a. m.	0.171	0.099	0.054	0.029	0.015	0.007	0.003	0.001	(*)					
7, 3:47 a. m.	0.280	0.147	0.069	0.030	0.017	0.009	0.003	0.003						
8, 6:05 a. m.														
9, 8:30 a. m.														
10, 11:00 a. m.	0.603	0.324												
11, 1:32 p. m.	0.372	0.184	0.085	0.032	0.012	0.007	0.005	0.005	0.011	0.017	0.034			
12, 4:00 p. m.	0.333	0.183	0.084	0.033	0.012	0.004	0.002	0.002	0.003	0.004	0.006	0.009	0.010	0.014

* Less than 0.0005 g./cu. m.

TABLE 6.—*Smoothed hourly values of wind direction and velocity above Fort Omaha, Nebr., observed 2:30 p. m., July 17, to 2:30 p m., July 18, 1914.*

Levels.	A. M.											
	1	2	3	4	5	6	7	8	9	10	11	12
312 m.: Direction	N. 70° E.	N. 86° E.	S. 79° E.	S. 66° E.	S. 50° E.	S. 27° E.	S. 7° E.	S. 14° W.	S. 82° W.	N. 86° W.	W.	S. 85° W.
Velocity (m. p. s.)	4.5	4.4	4.3	3.5	2.3	1.3	0.8	0.4	0.7	1.4	2.1	2.5
500 m.: Direction	N. 70° E.	N. 83° E.	S. 83° E.	S. 71° E.	S. 61° E.	S. 55° E.	S. 49° E.	S. 36° E.	N. 81° W.	N. 65° W.	N. 64° W.	N. 68° W.
Velocity (m. p. s.)	4.5	4.3	4.0	3.7	3.3	2.8	2.0	0.9	0.6	1.9	3.0	3.7
1,000 m.: Direction	N. 62° E.	N. 66° E.	N. 72° E.	N. 81° E.	S. 88° E.	S. 69° E.	S. 32° E.	S. 10° W.	S. 18° W.	S. 12° W.	S. 14° W.	S. 33° W.
Velocity (m. p. s.)	5.1	5.4	4.8	3.9	3.1	2.2	1.5	1.7	2.3	2.9	3.0	2.7
1,500 m.: Direction	S. 38° W.	S. 34° W.	N. 35° E.	N. 32° E.	N. 29° E.	N. 27° E.	N. 22° E.	N. 10° E.	N. 60° W.	S. 66° W.	S. 58° W.	S. 51° W.
Velocity (m. p. s.)	1.6	0.7	1.2	3.2	4.1	4.0	3.1	1.7	0.8	1.7	2.5	2.2
2,000 m.: Direction	N. 36° W.	N. 20° W.	N. 8° W.	N. 3° W.	N. 2° W.	N. 4° W.	N. 17° W.	N. 72° W.	S. 50° W.	S. 31° W.	S. 17° W.	S.
Velocity (m. p. s.)	1.9	2.0	2.8	3.4	3.4	2.7	1.7	1.0	1.6	2.6	3.0	3.1
2,500 m.: Direction	N. 63° W.	N. 62° W.	N. 54° W.	N. 41° W.	N. 30° W.	N. 30° W.	N. 48° W.	N. 69° W.	S. 86° W.	S. 17° W.	S. 29° E.	S. 39° E.
Velocity (m. p. s.)	3.3	3.0	2.6	2.3	2.0	1.6	1.5	1.7	1.4	1.0	2.3	3.5
3,000 m.: Direction	N. 29° W.	N. 41° W.	N. 50° W.	N. 47° W.	N. 34° W.	N. 29° W.	N. 32° W.	N. 39° W.	N. 40° W.	N. 19° W.	N. 41° E.	E.
Velocity (m. p. s.)	1.8	2.0	1.7	1.9	3.0	4.5	5.3	5.0	4.0	2.4	1.8	2.3
3,500 m.: Direction	N. 22° W.	N. 20° W.	N. 19° W.	N. 21° W.	N. 25° W.	N. 25° W.	N. 18° W.	N. 5° E.	N. 51° E.	N. 84° E.	S. 79° E.	S. 58° E.
Velocity (m. p. s.)	5.4	6.2	5.7	5.0	4.7	4.3	3.5	2.4	2.2	3.0	3.6	3.4
4,000 m.: Direction	N. 25° W.	N. 27° W.	N. 27° W.	N. 28° W.	N. 31° W.	N. 35° W.	N. 19° W.	N. 17° E.	N. 63° E.	S. 42° E.	S. 6° E.	S.
Velocity (m. p. s.)	4.5	5.0	4.7	4.1	3.5	2.9	2.1	1.7	1.3	1.3	2.8	3.7
,500 m.: Direction	N. 9° E.	N.	N. 12° W.	N. 81° W.	N. 76° W.	N. 67° W.	N. 67° W.	S. 81° W.	S. 28° W.	S. 10° W.	S. 8° W.	S. 12° W.
Velocity (m. p. s.)	1.8	1.2	1.7	2.6	3.2	3.6	3.0	1.9	2.1	2.9	2.8	2.5
5,000 m.: Direction	N. 6° W.	N. 38° W.	N. 65° W.	N. 88° W.	S. 87° W.	S. 87° W.	S. 82° W.	S. 56° W.	S. 10° W.	S. 13° E.	S. 24° E.	S. 36° E.
Velocity (m. p. s.)	1.9	2.3	2.3	2.8	3.6	4.3	3.7	2.5	2.3	2.8	3.0	2.7
6,000 m.: Direction	N. 82° E.	S. 54° E.	S. 22° E.	S. 3° W.	S. 24° W.	S. 38° W.	S. 45° W.	S. 51° W.	S. 55° W.	S. 62° W.	S. 71° W.	S. 82° W.
Velocity (m. p. s.)	1.5	1.4	1.6	1.7	2.0	2.3	2.5	2.8	2.8	2.7	2.4	2.1

Levels.	P. M.											
	1	2	3	4	5	6	7	8	9	10	11	12
312 m.: Direction	S. 80° W.	S. 80° W.	S. 80° W.	S. 76° W.	S. 62° W.	S. 53° W.	S. 58° W.	N. 84° W.	N. 9° W.	N. 23° E.	N. 39° E.	N. 54° E.
Velocity (m. p. s.)	2.9	3.4	3.5	3.0	2.4	2.0	1.5	1.0	1.3	2.6	3.6	4.3
500 m.: Direction	N. 73° W.	N. 79° W.	N. 83° W.	S. 86° W.	S. 63° W.	S. 36° W.	S. 25° W.	S. 25° W.	N. 45° E.	N. 37° E.	N. 47° E.	N. 59° E.
Velocity (m. p. s.)	4.2	4.8	4.8	4.1	2.9	2.6	2.3	1.4	0.1	2.0	3.4	4.2
1,000 m.: Direction	S. 67° W.	S. 77° W.	S. 79° W.	S. 78° W.	S. 84° W.	N. 84° W.	N. 63° W.	N. 40° W.	N. 19° W.	N. 11° E.	N. 42° E.	N. 57° E.
Velocity (m. p. s.)	3.3	4.1	4.5	4.2	3.6	3.1	2.8	2.6	2.4	2.0	2.7	4.0
1,500 m.: Direction	S. 40° W.	S. 34° W.	S. 21° W.	S. 9° E.	S. 30° E.	S. 33° E.	S. 29° E.	S. 23° E.	S. 14° E.	N. 45° W.	N. 76° W.	S. 49° W.
Velocity (m. p. s.)	1.6	1.1	0.9	1.2	2.0	2.4	2.1	1.3	0.4	0.3	0.4	1.1
2,000 m.: Direction	S. 17° E.	S. 23° E.	S. 26° E.	S. 32° E.	S. 49° E.	S. 63° E.	S. 76° E.	N. 18° E.	N. 34° W.	N. 35° W.	N. 36° W.	N. 38° W.
Velocity (m. p. s.)	3.1	3.6	3.9	3.8	3.2	2.2	1.2	0.3	1.4	2.4	2.7	2.4
2,500 m.: Direction	S. 42° E.	S. 42° E.	S. 42° E.	S. 45° E.	S. 62° E.	S. 83° E.	N. 47° E.	N. 3° E.	N. 21° W.	N. 37° W.	N. 48° W.	N. 57° W.
Velocity (m. p. s.)	4.3	5.4	5.8	5.5	4.7	2.3	1.6	2.1	2.8	3.5	3.8	3.7
3,000 m.: Direction	S. 56° E.	S. 41° E.	S. 35° E.	S. 29° E.	S. 19° E.	S. 12° E.	S. 11° E.	S. 14° E.	S. 22° E.	S. 37° E.	N. 11° E.	N. 21° W.
Velocity (m. p. s.)	2.9	4.0	4.5	4.6	4.2	4.0	3.8	3.3	2.4	1.0	0.5	1.4
3,500 m.: Direction	S. 35° E.	S. 18° E.	S. 7° E.	S. 1° E.	S. 2° W.	S. 1° W.	S. 1° E.	S. 4° E.	S. 6° E.	S.	N. 49° W.	N. 26° W.
Velocity (m. p. s.)	3.3	3.2	3.3	4.0	5.4	6.1	5.6	4.4	2.9	1.4	0.9	3.4
4,000 m.: Direction	S. 3° E.	S. 7° E.	S. 8° E.	S. 10° E.	S. 17° E.	S. 27° E.	S. 35° E.	S. 47° E.	S. 70° E.	N. 59° E.	N. 6° E.	N. 16° W.
Velocity (m. p. s.)	3.5	3.3	3.5	3.9	3.8	3.4	2.8	2.1	1.5	1.2	1.9	3.3
4,500 m.: Direction	S. 21° W.	S. 11° E.	S. 77° E.	N. 67° E.	N. 12° E.	N. 6° W.	N.	N. 47° E.	N. 85° E.	S. 80° E.	S. 80° E.	E.
Velocity (m. p. s.)	1.7	1.0	0.9	1.3	1.4	1.9	1.8	1.6	2.4	3.5	3.5	2.8
5,000 m.: Direction	S. 51° E.	S. 72° E.	N. 66° E.	N. 13° E.	N.	N. 7° E.	N. 32° N.	N. 41° E.	N. 83° E.	E.	N. 81° E.	N. 47° E.
Velocity (m. p. s.)	2.6	1.9	1.2	1.3	1.7	1.6	1.5	1.1	2.5	2.9	2.5	1.8
6,000 m.: Direction	N. 81° W.	N. 61° W.	N. 40° W.	N. 4° W.	N. 40° E.	N. 60° E.	N. 68° E.	N. 67° E.	N. 59° E.	N. 51° E.	N. 48° E.	N. 54° E.
Velocity (m. p. s.)	1.9	1.8	1.6	1.4	1.7	2.4	2.9	3.0	3.1	3.2	2.8	2.2

SECTION II.—GENERAL METEOROLOGY.

METEOROLOGICAL SYMBOLS.

By C. FITZHUGH TALMAN, Professor of Meteorology.

[Dated: Weather Bureau, Washington, D. C., Mar. 31, 1916.]

[The drawings for the symbols used in this paper were made by Mr. Harry Amer of the Drafting Room; the Editor wishes also to acknowledge the assistance of Miss Eleanor Buynitzky of the Weather Bureau library and of Mr. B. F. Larcombe of the Printing Division for special assistance in proofing, identifying, and sorting these symbols.]

I. SYMBOLS USED IN THE EIGHTEENTH CENTURY.

Various arbitrary symbols denoting the state of the weather or the occurrence of particular phenomena have been widely used in meteorological records and charts, in order to save space, and also to secure independence of local language. The use of such symbols appears to have been first suggested by J. H. Lambert, in 1771.[1] Lambert's symbols are shown in figure 1.

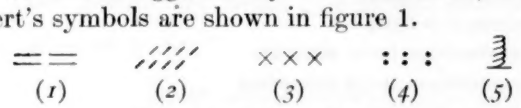

FIG. 1.—Lambert's Symbols, 1771.

1. Clouds. *2.* Rain. *3.* Snow. *4.* Fog. *5.* Thunder.
Duplication of a symbol denotes special duration or intensity. No entry=fair weather.

A much more elaborate set of symbols was used by the international observers of the Meteorological Society of the Palatinate, 1781–1792.[2] The symbols shown in figure 2 were used from the beginning of the observations, in 1781, except nos. 13, 14, 28, 29, 30, 31, and 32, which were introduced in 1782. Figure 3, reproduced in facsimile from the *Ephemerides* for 1792, includes, in addition to the symbols shown in figure 2, (*1*) astronomical symbols, (*2*) abbreviations relating to the shape and color of clouds and to the points of the compass, and (*3*) abbreviations and symbols in connection with atmospheric electricity.

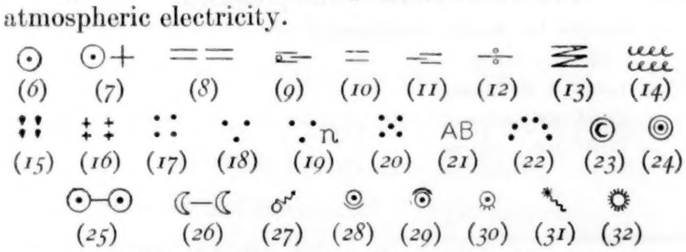

FIG. 2.—Symbols used by the Meteorological Society of the Palatinate, 1781–1792.

6. Cloudless. *7.* Cloudless but hazy. *8.* Overcast. *9.* Nearly overcast. *10.* Half cloudy. *11.* Slightly cloudy. *12.* Very slightly cloudy. *13.* Stratiform clouds. *14.* Cumuliform clouds. *15.* Rain. *16.* Snow. *17.* Hail. *18.* Hoarfrost. *19.* Rime. *20.* Fog. *21.* Aurora borealis. *22.* Rainbow. *23.* Lunar halo. *24.* Solar halo. *25.* Parhelion. *26.* Paraselene. *27.* Thunderstorm. *28.* Cloudy sunrise. *29.* Cloudy sunset. *30.* Sun "drawing water." *31.* Meteor. *32.* Fireball.
An asterisk (*) added to a symbol denotes special degree or intensity of the phenomenon. See also figure 3.

[1] Nouv. mém. Acad. roy. sci., Berlin, année 1771, p. 63.
[2] *Ephemerides Societatis Meteorologicæ Palatinæ*, Mannheim, 1785–95.

II. THE INTERNATIONAL SYMBOLS.

The International Meteorological Symbols were adopted at the Vienna meteorological congress of 1873. A few additions and modifications have been made at subsequent international meteorological meetings.

The forms of these symbols are more or less flexible. In the accompanying Table 1 (p. 268) the forms of the symbols shown in the first column are those which have generally been used in the United States, and with two exceptions ("wet fog" and "zodiacal light") are identical with those used by the Prussian Meteorological Institute and given in the German editions of the International Meteorological Codex. The principal variants found in the meteorological publications of various countries are shown in the second column. The English designations of the symbols follow the terminology of the English edition of the Codex, as modified by recent editions of the Observer's Handbook of the British Meteorological Office, except that the ambiguous expression "snowdrift" has been replaced by "driving snow"; and the term "haze" has been substituted for "dust haze," in order to include "optical turbidity" of the atmosphere (in accordance with the instructions of the Prussian Meteorological Institute). Explanations have been added where necessary.

Divergent Uses.—In addition to purely typographical errors occurring in various collections of the International Symbols heretofore published,[3] several more or less prevalent misapplications of certain symbols may be noted:

1. The symbols for halos and coronas, as adopted at the Vienna congress, are given differently in the three official versions of the *procès-verbaux*, as follows:

Phenomenon.	Symbols.		
	German.	French.	English.
Solar halo........	⊕	⦶	○
Solar corona........	⦶	⊕	⊕
Lunar halo........	Ʉ	ψ	ψ
Lunar corona......	ψ	Ʉ	Ʉ

[3] The symbol for hoarfrost is inverted in Smithsonian Meteorological Tables, 2d ed., 1897, and in several publications of the Weather Bureau. An erroneous symbol for lunar halo appears in Monthly Weather Review, July, 1898, p. 312, and in the Weather Bureau publication "Classification of Clouds and International Meteorological Symbols" (undated). The symbol for aurora is inverted in Monthly Weather Review, July, 1898, p. 312.

SIGNORUM METEOROLOGICORUM NOBIS USUALIUM EXPLICATIO.

☉ Coelum ex omni parte ſerenum.
☉+ Si in eo ſtatu pallidior ſolis ſtellarumque lux fuerit.
== Coelum totum nubibus tectum.
≡ Nubes majori coeli parti inductae, ſive continuae ſint, ſive disjunctae & quaſi pertuſae.
= Coelum nubes inter & caeruleum colorem ex aequo diviſum.
-= Nubes rariores, quae minorem coeli partem occupant.
S, -= vel ≡ Sol aut ſtellae micantes.
÷ Nubes rariſſimae, hinc inde diſperſae.
a. Albus.
c. Cinereus.
l. Luteus.
n. Niger.
r. Ruber nubium color.
rup. Nubes rupiformes (rupi ſimiles).
ſp. Nubes ſpiſſae.
t. Nubes tenues.
faſc. Faſciae (nubes in longas efformatae faſcias).
lact. Nubes lacteae, ſive eae, quae majores in diſcos efformatae, ac internitente coelo caeruleo diſtinctae, candore lac referunt.
≷ Nubes ductae, quaſi ſcopis planatae.
ꟺ Nubes, quas gregarias vocant.

⁞ Pluvia.
⁜ Nix.
∷ Grando.
∵ Pruina.
∵ n. Pruina, ſi nebulam conſtringit, eamque ramis arborum, crinibus &c. affigit
⁙ Nebula.
AB Aurora borealis.
⁖ Iris.
© Halo lunae.
◎ Halo ſolis.
☉—☉ Parelium.
☾—☾ Paraſelene.

♂ Tempeſtas cum tonitru & fulgure vel alterutru deficiente
✱ Eminens gradus cujusque meteorae.
◎ Ortus ſolis per nubes.
◎ Occaſus ſolis per nubes.
☉ Sol, ut ajunt, trahens aquas.
✱ Stella cadens.
O Globus igneus.

● Novilunium.
☽ Prima quadratura.
☉ Plenilunium.
☾ Ultima quadratura.
☾ Lunae proximus ad terrain acceſſus.
☾ Lunae longiſſimus a terra digreſſus.
☾ Luniſtitium boreale.
☾ Luniſtitium auſtrale.
☾a Aequinoctium lunae aſcendens.
☾∂ Aequinoctium lunae deſcendens
☉ Solſtitium boreale.
☉ Solſtitium auſtrale.
⊖a Aequinoctium ſolare aſcendens.
⊖∂ Aequinoctium ſolare deſcendens.
♈ Aries.
♉ Taurus.
♊ Gemini.
♋ Cancer.
♌ Leo.
♍ Virgo.
♎ Libra.
♏ Scorpio.
♐ Sagittarius, ſ. arcitenens.
♑ Capricornus.
♒ Aquarius.
♓ Piſces.

O Apeliotes.
S Notus.
W Zephyrus.
N Boreas.

Pro electricitate atmoſphaerica.

a. Attractio ſeu filorum divergentia.
a. f. Attractio fortis.
✱ Scintillae electricae.
+ Electricitas poſitiva.
— Electricitas negativa.

FIG. 3.—Meteorological and astronomical symbols and abbreviations used by the Meteorological Society of the Palatinate. (From the *Ephemerides* for 1792.)

⊙ *ſignificat coelum ex omni parte ſerenum, quo tamen in ſtatu ſi pallidior ſolis ſtellarumve lux fuerit, huic ſigno crux adjungitur* (⊙+);

= = *coelum totum nubibus tectum,*

≖ *nubes majori coeli parti inductas, ſive continuae ſint, ſive disjunctae & quaſi pertuſae,*

= *coelum nubes inter & caeruleum colorem ex aequo diviſum,*

-= *nubes rariores, quae minorem coeli partem occupant,*

+ *nubes rariſſimas, hinc inde diſperſas.*

Nubium color, forma & moles initialibus nominum literis exprimuntur. Sic litera

a *ſignificat albus,*	l *luteus,*
cin. *cinereus,*	n *niger,*
faſc. *faſciae (nubes in longas erfformatae faſcias, quarum directio indicatur),*	r *ruber,*
	ſp. *ſpiſſus,*
	t *tenuis,*
	rup. *rupiformis (rupi ſimilis).*

Qui ſpeciales de forma & coloribus nubium obſervationes inſtituerit, is opus perutile & magni momenti faciet.

X. Etiam extra conſuetas obſervandi horas notantur omnia meteora & phaenomena memoratu digna, cujusmodi ſunt pluvia, nix, grando, pruina, nebula, tempeſtates fulmineae, procellae, aurorae boreales, lux horizontalis, irides, terrae motus, fracturae nubium, columnae aqueae, halones, parelii, paraſelenae, globi ignei *&c. His ea ſignis diſtinquuntur:*

:: *indicat pluviam,*	⁖ *iridem,*
⁑ *nivem,*	© *halonem lunae,*
:: *grandinem,*	◎ *halonem ſolis,*
∵ *pruinam, quae ſi nebulam conſtringit, eamque ramis arborum, crinibus &c. affigit, ſigno huic litera* n *additur;*	⊙--⊙ *parelium,*
∵ *nebulam,*	☾--☾ *paraſelenen,*
AB *auroram borealem,*	♂ *tempeſtatem, ſive fulgur & tonitru conjuncta ſint, ſive alterutrum tantum habeat locum;*

cetera ſuis quaeque nominibus ſcribuntur. Sicui horum meteororum eminens quidam gradus convenerit, id appoſito aſteriſco (∗) *deſignatur. Sic* :: ∗ *pluviam largiſſimam,* ♂∗ *tempeſtatem violentam & atrocem ſignificat, & ita porro; & tunc non modo tempus initii ſed & finis meteori annotatur. Apparente meteoro inſigni & rariore, v. gr. aurora boreali, vehemente procella &c., etiam altitudo barometri, thermometri & hygrometri, una cum directione venti & declinatione acus magneticae, obſervatur.*

B 2 *XI.*

FIG. 4.—Instructions for the use of meteorological symbols. (From *Ephemerides Societatis Meteorologicæ Palatinæ*, 1781.)

TABLE 1.—*International Meteorological Symbols.*

Symbol.	Principal variants.	Meaning.	Remarks.
◉	●	Rain.	
✳	✳	Snow.	The symbol represents a snow-crystal, and should therefore be 6-pointed. The 8-point star is given in the English and Spanish editions of the Codex.
		Thunderstorm.	Thunder and lightning.
T	⌐	Thunder.	Without lightning.
	< ϟ	Lightning.	Without thunder; "heat-lightning."
▲	▲	Hail.	
△		Soft hail.	Ger., *Graupel;* Fr., *grésil.* Resembles little snow-pellets.
≡	≋	Fog.	The variant ≋ was used by the British Meteorological Office until 1912 and appears in the English edition of the Codex.
≡	≋	Ground fog.	Not exceeding the height of a man.
≡⁝	≡⁝ ≋⁝	Wet fog.	One which wets exposed surfaces.
⊔		Hoarfrost.	
⌓		Dew.	The inverted symbol has been used at the Observatory of Nuestra Señora del Recuerdo (Madrid). The Observatory of San Fernando (Spain) uses the ordinary symbol for dew (*rocío*), and the inverted symbol for evening dew (*relente*).
∨	∧ See remarks.	Rime.	A rough frost deposit from fog. The inverted symbol ∧ was formerly used at Zikawei Observatory. The Observatory of San Fernando (Spain) uses v̇ and v̲, to denote rime deposited in calm and windy weather, respectively. (Cf. Rept. Int. Met. Conf., Innsbruck, 1905, Engl. ed., p. 81.)
	~	Glazed frost.	Ice coating due to rain, "ice-storm." In America often called "sleet."
		Driving snow.	Ger., *Schneegestöber*; Fr., *bourrasque de neige.*
←	→	Ice-crystals.	Ice-needles sometimes seen floating or slowly falling in the air in clear, cold weather.
⊠		Snow on ground.	Ground near station more than half covered.
	See remarks.	Gale.	Wind of force 8–12, Beaufort scale. (Rept. Int. Met. Comm., Berlin, 1910, English ed., p. 17). Formerly used for "strong wind." A 3-barbed arrow is introduced in the 2d German ed. of the Codex to denote "strong wind," but no authority is cited. According to the Observer's Handbook, "the number of barbs on the arrow may conveniently be made to represent the strongest wind force noted," but there is no international sanction for such variants.
⊙		Sunshine.	In German edition of Codex, but has never been definitely recognized by the international organization. (See Rept. Int. Met. Comm., Southport, 1903, Engl. ed., p. 19 and 101). Widely used in German and Austrian publications.
⊕	⊕	Solar halo.	See accompanying text as to erroneous uses.
⦶		Solar corona.	
		Lunar halo.	
		Lunar corona.	
⌒		Rainbow.	
		Aurora.	
		Zodiacal light.	
∞		Haze.	Due to fine dust, or to the disturbance of atmospheric transparency by air-currents of different densities ("optical turbidity"), and not to water-drops. In practice, this is often difficult to distinguish from light fog (≡°), or "mist" of British observers. Prussian and Austrian observers underscore this symbol ($\underline{\infty}$) to denote a definitely *smoky* atmosphere ("Moorrauch"). The Observatory of the Agronomic Institute of Moscow uses ∞ for dry fog, and [∞] for haze.

NOTE.—Since the preparation of the above table the Weather Bureau has adopted the name "glaze" for the English "glazed frost" (Glatteis, verglas). Concerning "sleet" see p. 285.

No action was taken in regard to these discrepancies until 1891, when the International Meteorological Conference at Munich decided in favor of the German series. In the meantime, however, the symbols as given in the French and English versions of the Vienna *procès-verbaux* had been incorporated in the official instructions of numerous meteorological services, and both the French and the English series have been widely used down to a recent time.

2. A circular issued by the Weather Bureau January 1, 1894, states in connection with the symbol +→ :

> This symbol indicates that strong winds are raising the snow from the ground, filling the air with it like dust, and transporting it horizontally; this may occur under a clear sky. The symbol does not refer to snow falling from the clouds, nor to the mere fact that the snow is lying in drifts on the ground.

This statement is repeated in subsequent Weather Bureau publications and in Smithsonian Meteorological Tables, 2d ed., 1897, p. 265. On the other hand, the Prussian and Austrian official instructions to observers prescribe that this symbol shall *not* be used for snow that is merely blown from the ground.[4] Moreover, the German and French official designations of the symbol are "Schneegestöber" and "bourrasque de neige" (or "tempête de neige"), respectively, both of which usually imply the fall of snow from the clouds in connection with a windstorm. It appears, therefore, that there is no international authority for the American definition given above, which probably owes its origin to the use of the ambiguous term "snow-drift" in the English version of the report of the Vienna congress. In practice, however, when the air is filled with driving snow it is sometimes impossible to determine whether any part of it is falling from the sky.[5]

3. The symbol △ is defined as "sleet" in Smithsonian Meteorological Tables, 2d and 3d editions (1897, 1907), and in several publications of the Weather Bureau. Although the term "sleet" admits of various meanings, it is not properly applicable to the definite form of precipitation known as "soft hail," or "graupel," for which the above symbol was prescribed by the international organization.[6] [See p. 281, ffg.]

[4] "Unter *Schneegestöber* (+→) ist ein Schneefall bei lebhafteren Winden, welche die Schneeflocken durcheinander wirbeln, zu verstehen. Wird bereits lagernder Schnee vom Erdboden emporgewirbelt oder fortgeweht, so ist dies nicht als Schneegestöber (+→), sondern als Schneetreiben zu bezeichnen."—K. Preuss. Met. Inst., "Anleitung zur Anstellung und Berechnung meteorologischer Beobachtungen," 2d ed., 1904, pt. 1, p. 36.

[5] A number of special symbols for discriminating between different conditions under which the air may be charged with snow were used by Westman in the observations made in Spitsbergen by the Swedish expedition of 1899-1902. *See* J. Westman, "Observations météorologiques faites en 1899 et 1900 à la baie de Treurenberg, Spitzberg" (Stockholm, 1904), p. 32-33.

[6] Since about 1897 the Weather Bureau has applied the term "sleet" only to small particles of clear ice, falling with or without rain or snow. There is no international symbol for this form of precipitation. In the United States the word "sleet" is often applied to the ice coating due to falling rain ("glazed frost" of British usage). In Great Britain "sleet" commonly means a mixture of raindrops and snowflakes.

Exponents.—An exponent added to a symbol indicates the degree of intensity, ranging from ⁰ weak (light, etc.) to ² strong (heavy, etc.). Thus, ●^{0}, light rain; ●^{2}, heavy rain. German and French observers use the exponent ^{1} to denote medium intensity, in accordance with the German and French versions of the report of the Vienna congress, and the German editions of the Codex. The English version of the above-mentioned report and the English edition of the Codex provide for the use of only two exponents, ^{0} and ^{2}; hence in English-speaking countries the omission of the exponent indicates medium intensity.

Time of occurrence.—When hours of occurrence are added to symbols, the abbreviation *a* is used for a.m., and *p* for p.m. Thus, ● 10a – 4p denotes "rain from 10 a.m. to 4 p.m." The abbreviation *n* means "during night". Stations taking tri-daily observations may use *a* to mean between the first and second observation; *p*, between the second and the third; and *n*, between the third and the first.

III. OTHER SYMBOLS.

The following symbols differing either in form or meaning from the International Symbols are found in the literature of the 19th and present centuries. In view of the indefiniteness of many of the meteorological terms used in connection with these symbols, the explanations of the symbols are given in the original languages.

A. SYMBOLS USED IN METEOROLOGICAL REGISTERS.

Austria-Hungary.

Austria-Hungary. K. K. Hydrographisches Amt S. M. Kriegsmarine zu Pola. Jahres-Übersicht der meteorologischen Beobachtungen, 1874. (The first two of these symbols are given also in Jelinek's "Anleitung zur Anstellung meteorologischer Beobachtungen," Wien, 1869, p. 63.)

- • Nebel.
- ⁝ Regen.
- ↨ Gewitter.
- ↑ Blitz.

Canada.

Canada. Meteorological service. Instructions to observers. Toronto. 1878. p. 175.

⊕ Overcast, the whole sky being covered with impervious cloud.
◎ Clearing weather.
ʍʍ Misty, caused by condensed vapor.
↨ Flurries of snow.
Ⓥ "Visibility" of distant objects.
(Recognized by U. S. Signal Service n 1883. See note under *United States*.)

Chile.

Chile. Instituto central meteorológico y geofísico. Anuario meteorológico, 1912. Santiago de Chile. 1914. p. vii.

||| Llovizna, garúa.

≡b Jina de montaña.

▭ Relámpagos de calor, (de cordillera) resplandores eléctricos silenciosos.

⪯ Luz zodiacal.

Denmark.

Holten, C. Tables météorologiques de Copenhague, publiées sous les auspices de l'Académie royale danoise des sciences, 1866–1874. Copenhague.

○ Klar.
⊗ Blandet.
● Mørk.

France.

Montsouris. Observatoire physique central. Bulletin mensuel, 1872. Paris. 1875. tome 1. p. 386–387.

○ Ciel beau, sans nuages ou très-peu nuageux.
◔ Ciel peu nuageux, au quart couvert de nuages.
◑ Ciel nuageux, à moitié garni de nuages.
◕ Ciel très nuageux, aux trois quarts couvert.
● Ciel couvert, aux quatre quarts couvert.
O Brouillard durant toute la journée. Brouillard persistant.
O Vapeurs, brouillard se dissipant dans le jour, brumes à l'horizon.
∴ Rosée.
△ Gelée blanche.
▲ Gelée, glace.
Z Orage sans pluie.
Z or Z• Orage avec pluie.
▮ Grêle.
▯ Grésil.
◫ Vent du sud.
◪ Vent du sud-ouest.
⊟ Vent de l'ouest.
◩ Vent du nord-ouest.
◫ Vent du nord.
◪ Vent du nord-est.
⊟ Vent de l'est.
◩ Vent du sud-est.
⊡ Vent nul ou très-faible.
⊡ Vent faible.
⚁ Vent modéré.
⚂ Vent assez fort.
⚃ Vent fort.
⚄ Vent très-fort.
⚅ Vent violent.

Carlier, H. Observations météorologiques faites à Saint-Martin-de-Hinx, France (Landes), du 1 décembre 1875 au 30 novembre 1878. Bayonne. p. 2.

▲ Grêle.

Germany.

Jena. Grossherzögliche Sternwarte. Meteorologisches Jahrbuch, 1835, p. 1.

○ Ganz heiter.
⊙ Heiter.
□ Schön.
△ Wolkig.
═ Trübe.
⋕ Ganz trübe.
•• Thau.
** Reif.
† Nebel.
÷ Regenhaft.
÷ Einzelne Schneeflocken.
⁘ Regen.
⁕ Regen mit Schnee.
ꝏ Graupeln.
∞ Schlossen.
: Strichregen.
⁙ Landregen.
‡ Wetterleuchten.
↗ Blitz.
↗ Donner.
↗ Blitz und Donner.
╲ Sternschnuppen.
♂ Feuerkugeln.
◡ Morgen- oder Abendroth.
₢ Wiederschein.
⌒ Regenbogen.
☾Kr Mondkrone.
◉☾ Höfe um Sonne oder Mond.
○–○ Nebensonnen.
☾–☾ Nebenmonde.
⊖ Wärme im Sonnenschein.

Württemberg. K. meteorologische Zentralstation. Deutsches meteorologisches Jahrbuch. Stuttgart. (Current issues.)

F Lebhafter wind.

India.

India. Meteorological department. Instructions to meteorological observers in India, by Henry F. Blanford. Calcutta. 1876. p. 59.

§ Dust whirl or "devil."
↗ Dust storm.
↗ Hot wind.

Japan.

Japan. Central meteorological observatory. Monthly report. (Current issues.)

◷ Earthquake.

Netherlands.

Netherlands. Meteorologisch instituut. Meteorologische waarnemingen. Utrecht. (Issues previous to 1877, at about which time the international symbols were adopted.)

○ Helder.
⊙ Ligt bewolkt.
Bewolkt.
Zwaar bewolkt.
● Betrokken.
◎ Mist.
Dauw.
⊕ Donder.
⦶ Weerlicht zonder donder.

Russia.

Russia. Observatoire physique central Nicolas. Annales. Petrograd.

In current issues:

○ Pluie de glace. (Also used by the Meteorological Bureau of the Amur.)

|•| Colonnes lumineuses près du soleil. (This symbol is in general use in Russia.)

In early issues, prior to the introduction of international symbols:

8 Thau.
Reif.
△ Duft. Rauhfrost.
▲ Glatteis.
○ Nebel (oder Dunst in der Höhe).
□ Graupeln, Riesel.
■ Hagel.
Blitz.
⊙ Sonnenhof.
Mondhof.
Nordlicht.
Starker Wind.
Erdbeben.
Grêle.
Éclairs.
Tonnerre.
Tonnerre et éclairs.
○ Serein.
Couvert.
Nuageux.
Nuages disséminés.
Nuages à l'horizon.
Nuages legers.
Nuages legers à l'horizon.
Quelques nuages isolés.

Spain.

Granada. Observatorio meteorológico de Cartuja. Boletín anual. (Current issues.)

Bruma o niebla en el río.
○ Cielo despejado.
Cielo ¼ cubierto.
◐ Cielo ½ cubierto.
Cielo ¾ cubierto.
● Cielo cubierto.
Cielo cubierto con llovizna.

(The second, fourth and sixth of these symbols are also used by the Observatorio del Ebro.)

United States.

Formerly used by the Iowa Weather Service:

Thunderbolt. Lightning striking any object on the earth. (Adopted about 1877.)

<< or TB Thunderbolt. A flash of lightning having struck an object on the earth's surface, a tree, house, animal, etc., it is designated either by duplication of the symbol of lightning or by TB. (Adopted 1878.)

Zodiacal light. (Adopted 1878.)

Shooting star. (Adopted about 1877.)

Meteor, fireball. (Adopted about 1877.)

NOTE: In 1883 the U. S. Signal Service authorized the use by voluntary and State weather service observers of a set of symbols, comprising several of the International Symbols, the above symbol for zodiacal light, and the five symbols shown above under *Canada*. (U. S. Signal office, Circular No. 16, Oct. 18, 1883.)

Miscellaneous.

Kaltbrunner, D., & Kollbrunner, E. Der Beobachter. Allgemeine Anleitung zu Beobachtungen über Land und Leute, für Touristen, etc. 2.Aufl. Zürich, 1888. Taf. 21: "Meteorologische Zeichen."

Abendthau.
Morgenthau.
≈ Dünste.
≡ Leichter Nebel.
Starker Nebel.
Leuchtender Nebel.
Duftender Nebel.
Schwacher Regen.
Starker Regen.
Wolkenbruch.
Schneesturm.
Elektrisches Tosen.
St. Elmsfeuer.
Blitzschlag.
Luftspiegelung.
Doppelter Regenbogen.
or ⊕ Sonnenhof.
or Mondhof.
Nebensonnen.
Nebenmonde.
◎ or ⦶ Sonnenkrone.
⊙ or Mondkrone.
Sturm.
Wirbelwind.
Z Windhose, Wasserhose.
Cyclone.

B. SYMBOLS USED ON WEATHER MAPS.

Wind Arrows.

On all weather maps the direction of the wind is shown at each station by an arrow which flies with the wind.

As a rule the force of the wind is indicated by the number of feathers or tails attached to the arrow, according to the Beaufort or some other scale of wind force. On several European maps the force of the wind on the Beaufort scale is shown by means of feathers and half-feathers, thus: , force 1; , force 2; , force 3; etc. On the United States and Canadian maps the wind force is not indicated by symbols, but is given in miles per hour in the tabular portion of the map. On the Mexican weather map the force of the wind is shown by arrows as follows: débil; moderado; algo fuerte; fuerte; violento; huracán.

Calm (absence of wind) is usually indicated merely by the omission of the arrow, but a few special symbols for calm have been used; viz, ◎, ⊙, X, and C.

Symbols for Cloudiness.

The state of the sky with reference to cloudiness is usually indicated by the use or omission of shading inside a circle. Two principal systems have been used, as follows: ○ clear; ◔ ¼ cloudy; ◑ ½ cloudy; ◕ ¾ cloudy; ● cloudy; or ○ clear; ◑ partly cloudy; ● cloudy.

Various special symbols for cloudiness and other meteorological conditions are shown below.

Miscellaneous Symbols.

AUSTRIA-HUNGARY.

Pioggia. (Triest.)
Regen. (Vienna.)

BELGIUM.

Pluie. ⊕ Neige. ⊖ Brouillard.	In current use.
Serein. Pluie. Neige. Brume. Brouillard. (Later .) Orage. ○ Hausse barométrique. ● Basse barométrique. Baromètre stable.	In earlier use.

CANADA.

Ⓡ Rain.
Ⓢ Snow.
Ⓜ Report missing.

CHINA.

Orkan. ⊙ Regen.	Tsingtau.
○ Fair. ◐ Cloudy. Drizzle. ⊙ Overcast. ▣ Showers. Squally.	Zi-ka-wei.

EGYPT.

≡ From 0 to 4.9 mm. of rain (previous 24 hours).
||| From 5 to 9.9 mm. of rain (previous 24 hours).
⊞ More than 9.9 mm. of rain (previous 24 hours).

FRANCE.

○ Beau. Nuageux. Couvert. ⊖ Brumeux. ⊕ Brouillard.	In current use in France and Algeria.
≡ 0 à 5 mm. (pluie). |||| 5 à 10 mm. (pluie). ⊞ au dessus de 10 mm.	In earlier use in France.

GERMANY.

Telegramm fehlt. (Munich map.) Regen. / Schnee. — Dresden map.		In current use.
⊙ Anhaltend Sonnenschein. • Unbedeutender Regen. Unbedeutender Schnee. •• Zeitweise Regen. Zeitweise Schnee. Anhaltend schwacher Regen. Anhaltend Schneefall. Anhaltend starker Regen.	Dresden map—tabular portion.	

Regenmengen—24 Stunden.

• 1–5 mm. 6–10 mm. (Seewarte map.) 11–20 mm. über 20 mm.	In earlier use.

GREAT BRITAIN.

Wireless messages.

INDIA.

Rain.

(0 to 0.09 inch neglected.)
○ 0.10 to 0.17 inch.
.18 to .37 inch.
.38 to .67 inch.
.68 to .87 inch.
.88 to 1.24 inches.
1.25 to 1.74 inches.
1.75 to 2.50 inches.
2.51 to 3.49 inches.
&c., &c.

ITALY.

≡ Piovoso.
◍ Nebbioso.
△ Nevoso.

Cielò.

| ¼ coperto.
|| ½ coperto.
||| ¾ coperto.
|||| Tutto coperto.

Pioggia.

= da 0 a 5 mm.
≡ 5 a 15 mm.
≣ 15 a 30 mm
≣ oltre 30 mm.

JAPAN.

○ Clear.
⦶ Fair.
O Cloudy.
◍ Snow.
⊙ Fog.
◑ Thunderstorm.

NETHERLANDS.

Neerslag.

≡ 1–5 mm.
|||| 6–10 mm.
⊞ meer dan 10 mm.

PORTUGAL.

⊗ Ennevoado.

RUMANIA.

Ploaia sau zăpada.

≡ 1–5 milimetri.
||| 6–10 milimetri.
peste 10 milimetri.

RUSSIA.

: Dozhd'. (Rain.)

SPAIN.

○ Despejado.
⃠ Con nubes.
⊖ Bruma.
⊗ Niebla.
⊛ Nieve.

SWEDEN.

⋮ Regen.
▭ Nebel.
} These two symbols are given in W. J. van Bebber's "Handbuch der ausübenden Witterungskunde," Stuttgart, 1886, 2.Teil, p.55.

SWITZERLAND.

: Regen. (Pluie.)

UNITED STATES.

In current use:

R Rain.
S Snow.
▮⊖→ Storm warnings.
CW Cold wave warning.
→⊕→ Storm track and location of storm center.

In earlier use:

◔ Fair. (Later ◐.)
O Cloudy.
Ⓡ Rain.
Ⓢ Snow.
● Heavy rain.
◐ Light rain.
◍ Heavy snow.
⦶ Light snow.
○—▭ Cautionary signal. (Later ▯ ○.)
○—▬ Storm signal. (Later ▮ ○.)
⊕ Cloudy.
⊛ Rain.
⊖ Snow.
} Used by certain Weather Bureau stations.

C. SYMBOLS INDICATING THE STATE OF THE SEA.

ALGERIA AND FRANCE.

≡ Houleuse.
≋ or # Grosse.

FRANCE.

In earlier use:

• Calme.
•• Peu agitée.
∴ Agitée.
⸬ Houleuse.
⁝ Grosse.
⁘ Furieuse.

GREAT BRITAIN.

In current use:

∼ Rough.
≈ High.

In earlier use:

≡ Rough.
High.

ITALY.

› Mosso.
» Agitato.
⋙ Molto agitato.
⋙› Grosso.
⋙» Tempestoso.

PORTUGAL.

∼ { Estanhado. Plano. Chão.

≈ { Po. agitado. Agitado.

≋ { Pa. vaga. De vaga.

≋≋ { Vaga grossa. Tempestuoso. Mto. tempestuoso.

SPAIN.

{ Llana.
Rizada.

{ Marejadilla.
Marejada.

{ Marejada gruesa.
Gruesa.

{ Muy gruesa.
Arbolada.
Muy arbolada.

D. CLOUD SYMBOLS.

Ley, W. Clement. Cloudland. London. 1894. p. 26–27.

Scientific name.	*English name.*
Nebula.	Fog.
Nebula pulverea.	Dust fog.
Nebula stillans.	Wet fog.
Nubes informis.	Scud.
Stratus quietus.	Quiet cloud.
Stratus lenticularis.	Lenticular cloud.
Stratus maculosus.	Mackerel cloud.
Stratus castellatus.	Turret cloud.
Stratus precipitans.	Plane shower.
Cumulo-rudimentum.	Rudiment.
Cumulus.	Heap cloud.
Cumulo-stratus.	Anvil cloud.
Cumulo-nimbus.	Shower cloud.
Nimbus.	Rainfall cloud.
Cumulo-stratus mammatus.	Tubercled anvil cloud.
Cumulo-nimbus grandineus.	Hail shower.
Cumulo-nimbus nivosus.	Snow shower.
Cumulo-nimbus mammatus.	Festooned shower cloud.
Nimbus grandineus.	Hail-fall.
Nimbus nivosus.	Snow-fall.
Nubes fulgens.	Luminous cloud.
Cirrus.	Curl cloud.
Cirro-filum.	Gossamer cloud.
Cirro-velum.	Veil cloud.
Cirro-macula.	Speckle cloud.
Cirro-velum mammatum.	Draped veil cloud.

Howard, Luke. On the modifications of clouds. London. 1803. p. 14. (Hellmann's "Neudrucke," No. 3, Berlin, 1894.)

Cirrus.
Cumulus.
Stratus.
Cirro-cumulus.
Cirro-stratus.
Cumulo-stratus.
Cirro-cumulo-stratus, or Nimbus.

Formerly used by Iowa Weather Service. (Adopted 1876.)

Cirrus.
Cirro-stratus.
Cirro-cumulus.
Cumulus.
Pallio-cirrus.
Pallio-cumulus.
Fracto-cumulus.
= Polar bands, drawn as placed across the sky with → indicating motion; thus \\→ bands NW–SE moving toward the east.

E. LITERAL SYMBOLS.

In addition to arbitrary symbols, numerous literal symbols—usually the initial letter or letters of meteorological terms in various languages—have been used in meteorological registers and on weather maps. Only a few of these are included in the foregoing lists. The rest lie beyond the scope of the present compilation.

ON THE COEFFICIENT OF CORRELATION AS A MEASURE OF RELATIONSHIP.

By CHARLES N. MOORE.

[Dated: University of Cincinnati, Department of Mathematics, Apr. 17, 1916.]

In recent years several applications of the theory of correlation have been made in connection with meteorological investigations.[1] Consequently a brief discussion of the significance of a correlation coefficient and its reliability as a measure of relationship may be of interest to readers of the MONTHLY WEATHER REVIEW. The theoretical discussion in the present paper is in substance the same as that given by the writer in a recent paper in Science.[2] The bearing of that discussion on applications in meteorology is given here for the first time.

The theory of correlation deals with the relationship between two variable quantities whose variations are due in part or entirely to common causes. A certain quantity, r, known as a coefficient of correlation, is computed, and from its value inferences are drawn as to the extent to which the variations of the two quantities are affected in the same way by the same causes, or as to the extent to which the variation of one quantity affects that of the other.

The formula for r in terms of n pairs of observed values of two variables x and y, is

$$r=\frac{\sum_{i=1}^{i=n}(x_i-x_0)\,(y_i-y_0)}{\sqrt{\sum_{i=1}^{i=n}(x_i-x_0)^2\cdot\sum_{i=1}^{i=n}(y_i-y_0)^2}},\qquad(1)$$

where x_0 is the mean of the x values and y_0 the mean of the y values.[3] The value of r obtained from this formula

[1] See *J. Warren Smith* in MONTHLY WEATHER REVIEW, February, 1914, 42:78; and ibid., 1915, 43:222.
A. Sresnewsky, in Meteorologische Zeitschrift, Braunschweig, December, 1914, 31: 566.
L. Steiner, in Meteorologische Zeitschrift, Braunschweig, September, 1915, 32: 419.

[2] *Moore, Chas. N.* On the coefficient of correlation as a measure of relationship. Science, New York, October 22, 1915 (NS), 42:575–579.

[3] For an account of the process of computing r from a table of observed values of two variables see the paper by *J. Warren Smith*, MONTHLY WEATHER REVIEW, February, 1914, 42:79–80.

will never be less than -1 nor greater than $+1$, and in general will have a value lying between these two values. In case the variations of the two quantities depend entirely on common causes in such a way that one variable can be expressed in terms of the other by means of an equation, r *may* take on one of the extreme values $+1$ or -1. It *will* take on one of these values if one variable can be expressed *linearly* in terms of the other; i. e., if

$$y = ax + b,$$

where a and b are constants. In this case it will be $+1$ if $a > 0$ and -1 if $a < 0$; in all other cases it will have a value lying between these two values. In case the two variables are entirely independent of each other in the sense that their variations have no common causes, r will be zero or very near to zero if the number of observed values of x and y is large enough to eliminate the effects of chance. If the value of r lies between 0 and -1 or between 0 and $+1$, it may be due to the fact that there is a relation between the two variables that is not linear, or to the fact that the variations of the two quantities are not due to common causes in such a way that one can be expressed in terms of the other alone.

In general the variable quantities under discussion will have their variations subject to a great variety of causes. Let us assume, then, that

$$x = f_1\ (\epsilon_1, \epsilon_2 \ldots, \epsilon_m),$$
$$y = f_2\ (\epsilon_1, \epsilon_2 \ldots, \epsilon_m),$$

where $\epsilon_1, \epsilon_2, \ldots, \epsilon_m$ are m independent variables, and f_1 and f_2 are two different expressions in terms of those variables. If we are to be able to give any sort of definite interpretation to the value of r, it is necessary to assume further that the f's are, to a good degree of approximation, linear expressions in the ϵ's, i. e., that the equations

$$\begin{aligned} x &= a_{11}\epsilon_1 + a_{12}\epsilon_2 + \ldots + a_{1m}\epsilon_m, \\ y &= a_{21}\epsilon_1 + a_{22}\epsilon_2 + \ldots + a_{2m}\epsilon_m, \end{aligned} \qquad (2)$$

where the a's are constants, are approximately true. If now we represent the deviation of each ϵ from its mean value by a v with the corresponding subscript, we obtain readily from the last equations

$$\begin{aligned} x - x_0 &= a_{11}v_1 + a_{12}v_2 + \ldots + a_{1m}v_m, \\ y - y_0 &= a_{21}v_1 + a_{22}v_2 + \ldots + a_{2m}v_m, \end{aligned} \qquad (3)$$

where x_0 and y_0 are the mean values of x and y, respectively. It is evident that the mean value of each v is zero, since each represents the deviation of the corresponding ϵ from its mean value.

Suppose now that (v_i', v_j'), (v_i'', v_j''), $\ldots$ $(v_i^{(n)}, v_j^{(n)})$ are n pairs of observed values of v_i and v_j. Since the ϵ's are independent variables, we shall have if n is very large,

$$\sum_{r=1}^{r=n} v_i^{(r)}\, v_j^{(r)} = 0. \qquad (4)$$

For in that case there will be associated with each particular value of v_i a series of values of v_j whose mean is zero. Hence, if we collect terms involving the same values of v_i the sum of each set of terms will be zero, and therefore the whole summation in (4) will reduce to zero. For values of n small enough to make the computation of r practicable, equation (4) will in general be only approximately true. The larger n is, the better in general the approximation will be.

We will now substitute the values of $x-x_0$ and $y-y_0$ given by (3) in (1) and take account of (4) in making the substitution. We obtain

$$r = \frac{\sum_{i=1}^{i=m} a_{1i}a_{2i}\, s_i^2}{\sqrt{\sum_{i=1}^{i=m} a_{1i}^2\, s_i^2 . \sum_{i=1}^{i=m} a_{2i}^2\, s_i^2}}, \qquad (5)$$

where we have set

$$s_i^2 = \frac{v_i'^2 + v_i''^2 + \ \ldots\ + v_i^{(n)2}}{n} \qquad (6)$$
$$(i = 1, 2, \ldots m).$$

The s's thus defined are known as the *standard deviations* of the corresponding ϵ's. The formula (5) for r is well adapted to the discussion of the connection between the value of r and the degree of relationship between x and y.

To illustrate the way in which we can interpret the significance of r by means of equation (5) we will consider a particular example. Suppose the two variables x and y represent the wind velocities measured at the same instant in two different localities.[4] If the localities are not too far apart it is reasonable to suppose that the two velocities will depend in part on the same causes. Such a state of affairs will be represented mathematically by the equations in (2) if we suppose that the a's in the first equation corresponding to a certain set of the ϵ's are zero, and the a's in the second equation corresponding to a different set of ϵ's are zero.

We will suppose then that the first p of the a's in the first equation are zero and the last q of those in the second equation are zero, i. e., that

$$\begin{aligned} a_{11} = a_{12} = \ \ldots\ = a_{1p} = 0, \\ a_{2,m-q+1} = a_{2,m-q+2} = \ \ldots\ = a_{2m} = 0. \end{aligned} \qquad (7)$$

In order to begin with a fairly simple example we will suppose further that we are dealing with a case where each of the other a's involved is equal to a single positive quantity a, i. e., where

$$\begin{aligned} a_{1,p+1} = a_{1,\ p+2} = \ \ldots\ a_{1m}. \\ = a_{21} = a_{22} = \ \ldots\ a_{2,\ m-q} = a > 0. \end{aligned} \qquad (8)$$

It is readily seen that the s's defined by equation (6) depend upon the scales used in the measurement of the different ϵ's. Therefore there will be no loss of generality in supposing that these scales are so chosen that each of the s's is equal to a single quantity s, i. e., that

$$s_1 = s_2 = s_3 = \ \ldots\ s_m = s. \qquad (9)$$

If we substitute the values given by (7), (8), and (9) in (5), we obtain

$$r = \frac{(m-p-q)a^2s^2}{\sqrt{(m-p)a^2s^2(m-q)a^2s^2}} = \frac{m-p-q}{\sqrt{(m-p)(m-q)}}. \qquad (10)$$

We shall now make use of (10) to indicate one way in which the value of r throws light upon the relationship

[4] The correlation between two such variables is considered in the paper by *Sresnewsky* referred to above.

between a variation in x and a corresponding variation in y. Let us suppose that all the ϵ's on which x depends, i. e., all the ϵ's for which the corresponding a's on the right-hand side of the first equation in (1) are not zero, are increased by a certain quantity d, whereas all the other ϵ's, i. e., all the ϵ's on which y depends but x does not depend remain constant. If we represent by x' the new value of x, and by y' the new value of y after the increase in the ϵ's, then when we take account of equations (7), (8), and (2) we have readily

$$\begin{aligned} y' - y &= (m-p-q)ad, \\ x' - x &= (m-p)ad. \end{aligned} \tag{11}$$

Since the units in terms of which x and y are measured are in general arbitrary, it is apparent that we need to introduce some standard unit for each of them before we can attach any definite significance to a comparison of their changes in value. The natural way to choose a unit for this purpose is to relate its size in some definite way to the range of variability of the variable quantity concerned. This can be done by choosing as a unit the *standard deviation* of each variable. The standard deviations of the ϵ's, as stated above, are given by equation (6). The standard deviation of any other variable is defined in an analogous manner. Hence in view of equations (3), (4), (6), (7), (8), and (9), we have for the standard deviations of x and y

$$s_x = \sqrt{\frac{m-p}{n}}\,as, \quad s_y = \sqrt{\frac{m-q}{n}}\,as. \tag{12}$$

R may be said to be a good measure of the closeness of relationship between the two variables since it measures the extent to which a *typical* change in one variable causes a corresponding change in the other variable. If now we set

$$R = \frac{(y'-y)/s_y}{(x'-x)/s_x}, \tag{13}$$

we obtain from (11) and (12)

$$R = \frac{m-p-q}{\sqrt{(m-p)\,(m-q)}}.$$

Hence in this particular case $r=R$, and r may therefore be said to be a good measure of the degree of relationship between x and y.

It is easy to see, however, that cases may arise in which r and R differ considerably in value. Suppose, for example, that the a's of equation (2) satisfy the following conditions:

$$\begin{aligned} &a_{11} = a_{12} = \cdots a_{1p} = a_{2,m-p+1} = \cdots a_{2m} = 0, \\ &a_{21} = a_{22} = \cdots a_{2p} = a_{1,m-p+1} = \cdots a_{1m} = 10a, \\ &a_{i,p+1} \ = \cdots a_{i,p+2} = \cdots a_{i,m-p} = a. \quad (i=1, 2,), \\ &(m = 102p) \end{aligned}$$

Then we find by substituting in formulæ (5) and (13) that

$$r = 0.5, \quad R = 0.9.$$

Under still other suppositions the discrepancy between the values of r and R may be still greater. Hence it is apparent that r may not always be a good measure of the closeness of relationship between two variable quantities.

The chief conclusion to be drawn from the foregoing discussion is to a considerable extent a negative one. It is shown that it is possible to state conditions under which the coefficient of correlation as calculated from equation (1) will furnish a reliable measure of the degree of relationship between two variable quantities. But it is also shown that in cases where these conditions are not approximately fulfilled, the coefficient of correlation will not necessarily be a good measure of this relationship. As there seems to be no way of determining in any particular case whether or not the conditions we have stated are satisfied, it is apparent that considerable caution should be observed in drawing definite inferences from the value of a coefficient of correlation.

RAINFALL IN CHINA, 1900-1911.[1]

By CO-CHING CHU, A. M.

[Dated: Cambridge, Mass., Mar. 21, 1916.]

INTRODUCTION.

As the fluctuation in rainfall from year to year is great, it is always a difficult matter to discuss the subject and draw isohyets with accuracy and intelligence unless we have a long series of reliable observations well distributed over the region under discussion.

China has been backward on all subjects meteorological. The data on rainfall in China are mostly spasmodic, inaccurate, and limited to recent years only. The data on rainfall in this article are based on Rev. Louis Froc's work "La Pluie en Chine, durant une period de onze années, 1900-1911," published by the Catholic Mission of Zi-ka-wei, Shanghai, China. These are, no doubt, the most recent and at the same time the most reliable data on the rainfall in China. In all, there are 88 stations, divided into four classes according to the length of the record of rainfall. In the first class, which comprises 34 stations, all except 4 have data extending through the period of 11 years. The records of the remaining stations are incomplete, varying in length from eight to two or three years. The stations are not very well distributed, but are concentrated mostly along the coast and the valley of the Yangtze River; in the northwest they are entirely wanting. The area of China proper, according to Mill's International Geography, is approximately 1,300,000 square miles. Assuming that all the data of the 88 stations were available and that they were uniformly distributed, there still would be only one station to every 1,500 square miles.

It is evident that a rainfall map based upon these data can only be tentative. If the stations were more numerous and better distributed, and if the records extended over a longer period, the map would be probably quite different from what it is.

RAINFALL CONTROLS.

In the main, there are three factors which control the amount and seasonal distribution of precipitation in China, (1) the monsoon, (2) the topography, and (3) the cyclonic distribution.

(1) *Monsoon.*—The monsoon[2] is a seasonal wind which is best developed in Asia, owing to the vastness of

[1] A study offered as part of the requirements for the degree of A. M. at Harvard University in 1915; prepared under the direction of Prof. A. G. McAdie and R. De C. Ward.

[2] Whether the summer southeast wind in China should be called "monsoon" or "trade wind" is controversial according to Mr. B. C. Wallis. See the extract from a paper by him, MONTHLY WEATHER REVIEW, January, 1915, 43:24.

that continent. The Siberian HIGH in winter and continental LOW in summer make eastern Asia specially favorable for the development of that wind.

Along the Chinese coast the wind is on-shore and wet in summer and offshore and dry in winter. The wet or southeast monsoon can be best appreciated in southern and central China along the coast. In Hongkong or even in Shanghai the summer wind is usually humid and heavily laden with moisture, which, coupled with high temperature, gives one an oppressive and "muggy" feeling. The dry or northwest monsoon is best developed in northern China, where the winter is unusually dry and dusty.

The following wind percentages along the Chinese coast are taken from the United States Hydrographic Office pilot chart for the year 1914–15.

TABLE 1.—*Percentages of the predominant winds along the Chinese coast.*

Month.	Yellow Sea.	Estuary of the Yangtze.	Formosa Channel.
January	N., 30; NW., 22	N., 35	NE., 55.
February	N., 25	N., 30	NE., 55.
March	NW., 18; N., 15	NE., 20	NE., 50.
April	SE., 18	SE., 22	NE., 35.
May	S., 25	SE., 28	NE., 40.
June	SE., 25; S., 20	SE., 30	SW., 28; NE., 20.
July	S., 25	S., 25; SE., 25	SW., 28; S., 18.
August	S., 15	SE., 25	SW., 18; NE., 18.
September	N., 20	NE., 28	NE., 40.
October	N., 25	NE., 30; N., 25	NE., 63.
November	N., 14	NW., 14; N., 12	NE., 60.
December	N., 32; NW., 25	NW., 25	NE., 55.

From the above table we see that the wind on the southern coast is much more steady than on either the northern or the central coast. From October to March the wind at Hongkong or its neighborhood is northeast 50 per cent of the time or more. Only in the three summer months is the prevalent wind from south or southwest. The north or northwest wind is almost nil in this part of the coast. The northeast wind is the regular Trade, which greatly decreases in strength along the central and northern coasts, while the northwest wind in winter and southeast in summer gradually increase in their percentages.

(2) *Topography.*—The topography [3] of China proper is quite mountainous. Roughly speaking, about 50 per cent of the country is above the 1-kilometer contour. Unlike the highlands in the United States, the Chinese highlands are in the form of plateaux and not in the form of mountains or ridges. In the south the coast is quite steep, while in northern and central China, owing to the delta of the Yellow River and the Yangtze, the coasts are usually low with the exception of the region near the Shantung Peninsula.

(3) *Cyclonic distribution.*—There are three main paths of cyclones: (*a*) Those storms which originate in Siberia, Mongolia, and Manchuria; (*b*) those which originate in China proper and Thibet; and (*c*) those which originate in Pacific Ocean, Eastern Sea, or Yellow Sea.

The data on the storm tracks contained in this article were taken from the meteorological reports published in Zi-ka-wei, Shanghai, for the years 1901–1910. The storms were studied individually and classified according to their origin. The Siberian storm usually originates west of Irkutsk, and travels east, crossing eastern Mongolia, southern Manchuria, and thence to northeastern China in Chi-li or Shantung; or more often from Manchuria directly enters the Japanese Sea and thence to Okhotsk Sea. The direction southeastward changes to northeastward, and the average time for the passage is about six days. These storms may also originate in Mongolia or Manchuria. The storms of the second group usually have their low centers first appear south of the Lake Tongting or in the Province of Szechuang, and arrive at the coast near Nanking on the second day, and leaving it on the third for the Eastern Sea, whence they go to Okhotsk Sea by way of the Japan Islands. The direction of the storm path on the continent is eastward. The centers of low pressure that originate in the Pacific are mostly what are known as typhoons or baguios. The storm track of this group has been extensively studied by Algué and others.[4] In winter the storms are usually far from the continental coast and exert little or no influence on the rainfall in China, while in summer and early autumn they bring the heaviest rainfall. The storms in summer develop near or east of the Philippine Islands, pass thence to eastern Chinese coast and northwestward over the Japanese Sea or Japan Islands toward Kamchatka. In the summer no storm track can be traced over Bering Sea and the extreme northeast Pacific coast.

The meteorological reports of Zi-ka-wei also contain the daily rainfall data of 41 stations in China for the years 1901–1908, and at 70 stations for the years 1909–1910. Some of the additional stations are Japanese stations. The number of storms recorded increases with years, and the location of the low centers is more clearly indicated in the later years, owing to the increase in the number of stations.

Some of the storms reported by the Zi-ka-wei Observatory are too far off in the ocean to affect the rainfall in China and a few pass too far north in Siberia. The following 626 storms, which passed across or near China proper, Manchuria, and the neighboring seas, were classified according to origin.

TABLE 2.—*Classification of 626 storms that passed across or near China.*

Month.	Siberian type.	China proper type.			Typhoons.		Total.
		North China.	South China.	Eastern Sea.	In ocean.	On coast.	
January	12	3	23	7	0	0	45
February	9	7	16	5	4	0	41
March	20	4	21	7	4	0	56
April	28	7	25	3	4	0	67
May	26	11	19	1	12	0	69
June	17	5	26	3	9	4	64
July	6	6	8	3	14	14	51
August	1	5	2	1	16	20	45
September	7	2	5	3	19	13	48
October	11	5	11	2	19	8	56
November	18	4	9	3	10	1	45
December	16	5	12	1	4	0	38
Total	**171**	**64**	**177**	**39**	**115**	**60**	**626**

The storms are well distributed as to the months. There are two maxima, one in spring and the other in late fall. The first is due to the frequency of the Siberian and China proper storms and the second to the great number of typhoons in the autumn. The velocity of these storms increases from summer to winter. For the storms of the first two types the velocity varies from 20 to 40 miles (9–18 m. p. s.) an hour in winter and from 15 to 25 miles (7–12 m. p. s.) an hour in summer. For the

[3] For a comprehensive description of the topography of China, see Mill's International Geography, chapter on China. The best topographic map is probably the one contained in L. Richarde's "Comprehensive Geography of China," Shanghai, 1907. See also the photographic reproduction of a German hypsometric map of China (given by Blackwelder) in Report of the Smithsonian Institution for the year ending June 30, 1913, Washington, 1914, p. 386.

[4] For tracks of typhoons, see among other works *Algué's* "Cyclones of the Far East," plate 40.

typhoon the hourly velocity averages about 20 miles (9 m. p. s.) in winter and about 18 miles (8 m. p. s.) in summer. The storms that originate in the Eastern and Yellow Seas are not typhoons, but belong to the second group, as can easily be seen by their monthly distribution.

MEAN ANNUAL RAINFALL.

There are three separate rainfall districts in China: *First*, north China, where the mean annual amounts to about 50 to 100 centimeters. As winter in north China is unusually dry, more than 60 per cent of the rain falls in the three summer months, when it is most needed for wheat, barley, and other important crops. The maximum comes in July or August and the minimum in February. *Second*, the Yangtze Valley, where the mean annual amount varies from 100 to 150 centimeters, decreasing very gradually from the coast inland. Here winter rainfall is more abundant than either in north or south China, although the amounts are small. The maxima for most of the stations come in July and the minima in December. The secondary minima in May, and the secondary maxima in January, are also typical. The *third* district is south China, where the mean annual fall is 150 to 200 centimeters along the coast and 100 to 150 centimeters at the inland stations. The percentages of rainfall in summer here again increase. The maxima come usually in June, but sometimes in August.

FIG. 1.—Mean annual rainfall of China (centimeters).

Besides these three divisions, the island stations need to be grouped separately. It has been pointed out by Supan [5] that the rainfall on the islands along the Chinese coast, instead of exceeding that on the continent, actually decreases. The islands have a lower mean annual fall than have the continental stations on the same latitude, and this is specially true in the south.

[5] See Hann, Klimatologie, 1911, v. 3, p. 305.

TABLE 3.—*Chinese stations used in the present study, with annual rainfall reduced to the period 1900–1911.*

Station.	Latitude (North).		Longitude (East).		Altitude.	Mean annual rainfall.	Length of record.
	°	'	°	'	*Meters.*	*Mm.*	*Years.*
NORTH CHINA:							
Aigun	49	50	127	38	136	432.5	9*
Harben	45	46	126	50	147	564.0	9
Mukden	41	48	123	23	44	598.2	6
Newchwang	40	41	122	16	3	638.2	8½
Chemulpo	37	29	126	32	14	952.4	11
Chefoo	37	33	121	22	3	587.8	11
Tsingtau (Kiaochow)	36	04	120	19	79	718.2	11
Tamingfu	36	18	115	18	(?)	580.8	11*
CENTRAL CHINA:							
Ningpo	29	57	121	45	10	1,331.0	11
Shanghai	31	12	121	26	7	1,161.2	11
Chenkiang	32	13	119	25	12	1,118.6	11
Wuhu	31	20	118	20	15	1,300.7	11
Kiukiang	29	45	116	08	20	1,610.3	11
Hwohkiu	32	22	116	15	(?)	1,010.6	11*
Hankow	30	35	114	17	36	1,112.7	11
Ichang	30	42	111	16	51.5	1,035.8	11
Chungking	29	34	106	31	230	1,024.9	11
Yunnanfu	25	04	102	49	1,980	1,098.5	8
Chengtu	30	40	104	03	518	881.5	11*
SOUTH CHINA, COAST:							
Wenchow	28	01	120	40	3	1,558.4	11
Foochow	25	58	119	27	20	1,514.6	11
Amoy	24	27	118	05	4	1,175.7	11
Swatow	23	23	116	40	4	1,509.5	11
Shanshui	23	06	112	53	10	1,757.9	11
Hongkong	22	18	114	10	32	2,034.7	11
Pakhoi	21	29	109	07	5	1,985.5	11
SOUTH CHINA, INTERIOR:							
Wuchow	23	29	111	20	2	1,339.8	11
Nanning	22	42	108	03	122	1,110.1	11
Lungchow	22	22	106	45	(?)	1,994.3	11
ISLAND STATIONS:							
Shantung Cap	36	54	122	32	12	725.3	11
Chawei Shan	31	25	122	14	53	989.4	11
Gutzlaff	30	49	122	10	75	1,078.0	11
North Saddle	30	52	122	40	72	1,020.0	11
Steep Island	30	13	122	35	63	914.0	10
Peiyushan	28	53	122	16	82	1,127.9	7
Tongyong	26	33	122	30	111	799.3	6
Middle Dog	25	58	119	59	59	1,181.7	7
Turnabout	25	26	119	56	65	996.9	11
Oksseu	25	00	119	17	62.5	844.1	11
Chapel Island	24	10	118	30	55	1,035.0	11
Pescadores	23	30	119	45	11	1,024.5	(?)
Lamocks	23	16	117	17	58	1,079.4	11
Tainan	22	45	120	15	9	1,676.6	(?)
Kelung	25	15	121	45	(?)	3,422.8	(?)

In all there are 44 stations. Most of them have records for the whole period of 11 years. Those marked with an * in the last column have records for less than 11 years, but they have been reduced to this period by comparison with a neighboring station of longer record. The method of reduction has been as follows: Suppose that station A has an incomplete record, let x be its mean annual rainfall for the observed period. Call the neighboring station with a record for the whole 11 years station B and let R be the mean annual rainfall of B for the whole 11 years, while S is the mean annual rainfall of B for the years corresponding to the record at A. If we call y the mean annual rainfall of A for the 11 years, then

$$y = R\frac{x}{S}.$$

The accuracy of the mean corrected annual rainfall, ascertained in this manner, depends upon both the distance and the difference of altitude between the two stations A and B. The incomplete records of some of the isolated stations have to be left uncorrected.

Of the 8 northern stations only 3 have complete records. Among the 11 stations along the Yangtze, 8 stations have complete records, and all 10 of the southern stations are complete. Among the island stations 3 records, taken from the Journal of the Meteorological Society of Japan for 1915, are of unknown period.

TABLE 4.—*Monthly percentages for the composite stations.*[6]

Month.	North China (3 stations).	Central China (4 stations).	South China (4 stations).
	Per cent.	*Per cent.*	*Per cent.*
January	1.5	6.1	2.5
February	0.8	4.1	4.2
March	2.4	8.3	6.1
April	4.5	10.7	9.4
May	7.5	8.4	11.5
June	11.1	14.9	16.0
July	26.4	16.0	12.2
August	24.6	11.0	14.0
September	9.7	7.1	12.6
October	5.5	6.9	5.4
November	3.0	3.5	2.9
December	3.1	2.9	2.8

The records of north China are taken from the three stations Newchwang, Chefoo, and Tsingtau; those of central China from the following four stations: Shanghai, Chenkiang, Wuhu, and Kiukiang; and those of south China taken from the four stations Wenchow, Foochow, Swatow, and Hongkong.

The predominant influence of the monsoon is plainly seen in the decrease of precipitation from south to north, and the marked summer maxima. Exceptions are to be found to the first statement, but they can be explained as due to the topographical or other local causes. Thus, the mean annual amount at Chefoo is distinctly less than that at Tsingtau, although they are only a little distance apart. The difference is owing to the rugged mountains in the Shantung Peninsula, which has an elevation of about 1,800 meters at its highest point. Since the wind is northerly in winter and southerly in summer, and since precipitation comes mostly with the southerly wind, the result is that in both summer and spring Tsingtau has more rainfall, and only in winter, the dry months, does Chefoo receive more precipitation, The difference between the mean annual falls is more than 12 centimeters.

The Yangtze stations in Table 3 are arranged according to the longitude. The uniformity of distribution along the valley of the Yangtze is noteworthy. The difference in precipitation between Shanghai, on the coast, and Chentu, which is more than 1,500 miles from it and approximately at the same latitude, is only 28 centimeters. Hence, the isohyets along the Yangtze are almost parallel to the latitudes, and the gradient is very small compared with that on the southern coast. This is probably due to the fact that while the elevation of land along the Yangtze is gradual the slope of the southern coast is much steeper.

As stated before, the mean annual amount decreases from south to north. As a whole this is true, but on the southern coast we find a notable exception in the case of Amoy. The deficiency of precipitation in the region around Amoy can be seen plainly on the mean annual map (fig. 1). The probable explanation is to be found in the rain-shadow effect caused by the high mountains in eastern Formosa. Indeed, that effect is more marked on the islands in Formosa Strait and on the stations on the western coast of Formosa itself. Thus, while Kelung situated at the northeast of the mountain, has a mean annual of 342 centimeters, Tainan on the western side of it, has a little less than half that amount and the island stations in Formosa Strait less than a third. The deficiency is more marked in Amoy than in Foochow or Swatow, partly because Amoy is almost at the center of the rain shadow and partly because there are some hills around Amoy.

All the 44 stations have the maximum in summer, with the exception of Kelung, on the east coast of Formosa, where the maximum comes in late autumn or winter. The maxima in northern China, as already pointed out, occur about a month later than those in southern China. The minima of the northern stations come also late in February. Without a single exception, among the lower Yangtze stations up to Hankow, there is a decrease of rainfall in the month of May. On the coast from Ningpo to Hongkong, with the exception of Amoy and Swatow, which are unduly influenced by the rain shadow effect of Formosa, the mean monthly amount for July is distinctly less than either that of June or August. This latter fact has been pointed out by Julius Hann in his Climatology.[7]

The July minimum was long known to the Chinese living in the south; but they described it as two maxima, one in early summer [8] and one in late summer. Baron von Richthofen in his letter on the Provinces of Chekiang and Nghanhwei, also mentioned the fact that while he was traveling in southern part of Chekiang in the month of July he was not seriously detained by rain, which was a great advantage over the traveling in the northern Provinces at that period.

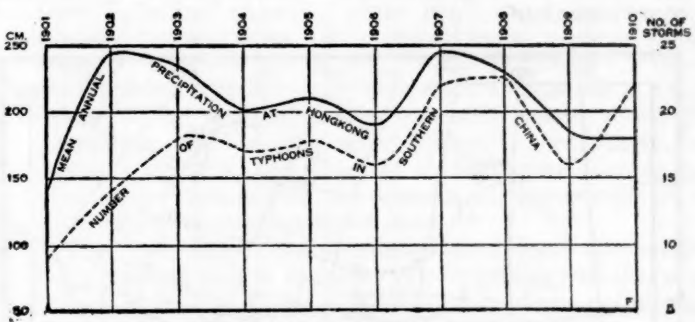

FIG. 2.—Annual march of precipitation at Hongkong compared with the annual numbers of typhoons over southern China (1901–1910).

The July minimum along the southern coast can be explained, at least in part, by the wind direction. The following percentages of wind direction were taken from the pilot chart of United States Hydrographic Office. From Table 5 a comparison between the wind directions in the months of June, July, and August can be made.

TABLE 5.—*Percentages of wind directions along the southern Chinese coast.*

Month.	NE.	E.	SE.	S.	SW.	W.	Wet.	Dry.
June	20	12	12	18	26	0?	62	26
July	12	13	12	17	26	9	54	35
August	18	12	13	13	18	0?	56	18

Under the column "Wet" are included winds from northeast, east, southeast, and south; and under the column "Dry" are included winds from west and southwest. The sum total of percentages of each month is not 100, owing to certain directions not shown in the chart.

[6] Hann, op. cit., vol. 3, p. 304.

[7] *Hann*, op. cit., v. 3, p. 305.

[8] The early-summer rain of southern China is also known as the "season of the plum rain," as was pointed out by Prof. *T. Okada* in his paper, "The rainfall of China and Korea," this REVIEW, November, 1905, 33:479 (Jour., metl. soc. Japan, Sept., 1905).

The relatively high percentages of precipitation in central China in winter is probably due to the storms of the second group, which usually travel along the valley of the Yangtze. By examining the table of storm frequency (Table 2) we see that the Siberian and the China-proper types of storms all have their maxima in winter and spring. A further inspection of the daily rainfall data reveals the fact that the Siberian storms usually give only cloudiness in northern China, although causing precipitation in the Japanese Islands. The storms of the second group, however, usually give rise to rainfall, specially when they take the Yangtze route. When this type of storm travels along the valley of Yellow River, the precipitation is usually light.

South China from Foochow and Yunnanfu southward is rarely affected by the storms of the first or second groups. The rainfall in this region mostly comes with a typhoon. In order to see whether there is any correlation between the number of typhoons and the mean annual rainfall of south China, curves of the number of storms in the 10 years 1901–1910 and the mean annual rainfall of Hongkong were plotted in the diagram, figure 2. There is some resemblance between the two curves, although it is not very close.

To determine the storm type and its relation to rainfall and cloudiness, six storms were chosen, one each to represent Siberian, Mongolian, south and north China, and the coast and ocean typhoons. The tracks of these LOWS were drawn on the map presented in figure 3. These storms are, in general, representative of their respective types. They are all taken from the last two years in order to have the data of the accompanying daily rainfalls more complete.

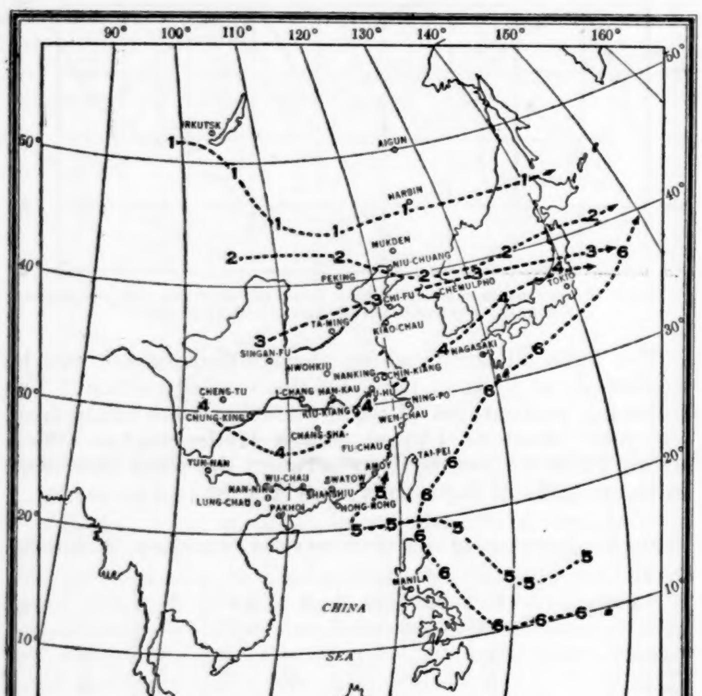

FIG. 3.—Typical tracks of storms of different origins crossing China and Japan.

The successive 24-hour a. m. positions of the storms are indicated by the locations of the respective figures, 1, 2, 3, etc. The types and their respective dates are as follows:
1—Siberia type, January 2–7, 1910.
2—Mongolia type, April 1–5, 1910.
3—North China type, May 31–June 3, 1910.
4—Yangtze Valley type, June 11–16, 1910.
5—Coast typhoon, October 14–20, 1909.
6—Ocean typhoon, May 3–12, 1910.

The amounts of rainfall recorded at different stations during each storm are taken from the Zi-ka-wei Observatory reports; the figures given are as follows:

Storm No. 1, Siberia type, January 2–7, 1910; with the exception of Mukden, where the amount was 1.8 millimeters on January 4, 1910, there was no precipitation in China. In Japan, on the 8th, Tokyo received 2.4 millimeters, and several other Japanese stations recorded light rainfall.

Storm No. 2, Mongolia type, April 1–5, 1910; on April 3, 1910, Newchwang received 3.8 millimeters, Takou 1.0 millimeter; the rest of the northern Chinese stations had clear weather; while Nemuro (lat. 43°N., long. 145°E.) on the 5th had 18.9 millimeters.

Storm No. 3, North China type, May 31–June 3, 1910; in north China, Chefoo had 54 millimeters on June 1, 1910, and Newchwang had 37 millimeters as the total of three days. The rest of the northern stations all had light rain, while the Yangtze and southern stations were all clear. Tokyo received 50 millimeters.

Storm No. 4, Yangtze Valley type, June 11–16, 1910; of the northern stations Newchwang had 1.3 millimeters, Tientsin 32.5, Chefoo 30, and Tamingfu 106. Of the central China stations the total amount received was: Chungking 3.0, Ichang 47.5, Chentu 0.0, Hankow 144.0, Shanghai 166.5, and Ningpo 51.4. Of the southern stations, Wenchow had 7.9 millimeters, Foochow 10.3, Amoy and Swatow had no precipitation, Hongkong had 2.3. In Japan, Tokyo received 50 and Nagasaki 232 millimeters.

Storm No. 5, Coast typhoon, October 14–20, 1909; the stations which had precipitations were Foochow with 50 millimeters, Amoy 48, Swatow 20.4, Hongkong 327.2, Shanshu 192.6, and Wuchow 43.2. Pakhoi and Lungchow had none.

Storm No. 6, Ocean typhoon, May 3–12, 1910; this particular typhoon had no effect on southern China. The central Chinese coast was cloudy.

FIG. 4.—Rainfall isomers for China for the three summer months (1900–1911).

In general, we can say that with the exception of storms belonging to Type No. 5, which disappear while on the continent, those of the remaining five types converge upon the northern Japanese islands and then disappear over the Pacific; some can be traced even to the Pacific coast of North America.

Types 1 and 2 give very little rainfall, and Type 3 only light rainfall in northern China and no effect at all in central or southern China. Type 4 gives quite heavy rainfall at lower Yangtze stations, but only light rainfall over the upper Yangtze region, the southern, and the northern coast. Type 5 is the heaviest rain bringer to southern China, but it has little effect in central China and the LOW seldom goes up to Shantung. No. 6 has but little influence on the precipitation of China, and usually comes in winter.

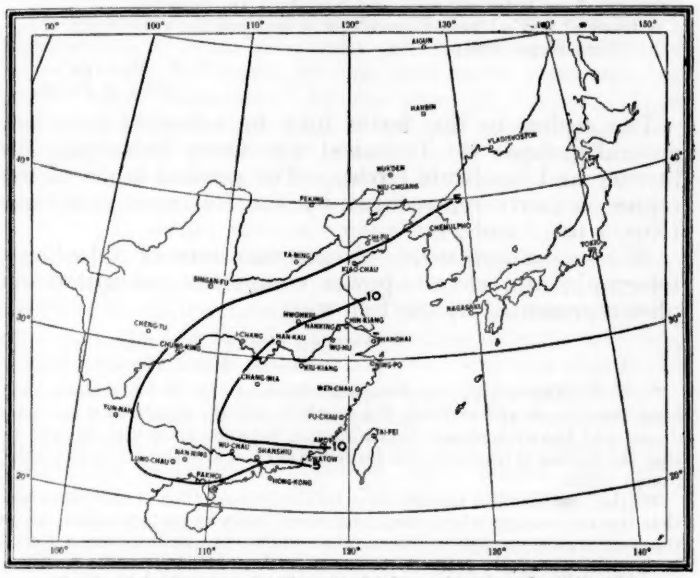

FIG. 5.—Rainfall isomers for China for the three winter months (1900-1911).

The stations Foochow, Amoy, and Swatow are so unfavorably situated that they receive only light rainfall during the storms of Types 4 and 5 when there is heavy rain to the north and south of them. This causes a deficiency of precipitation at those stations and they receive less than their position would seem to entitle them to.

Tornadoes.—There was only one tornado throughout the whole period, and that was in 1902 in Shantung.

ABSOLUTE DAILY AND MONTHLY MAXIMA, AND SNOWFALLS.

Pakhoi, the southernmost station, has the distinction of having the highest extreme annual, monthly, and daily maxima. These occurred in three different years. The extreme annual maximum is 2,691.3 millimeters, or about 100 inches. Such amount is of common occurrence in the United States, specially on the high mountains of the Northwest. The extreme monthly maximum at Pakhoi occurred in July, 1900, and the amount is 952.9 millimeters; and the daily maximum occurred June 27, 1903, the amount being 319.5 millimeters, or about 13 inches. The maximum daily rainfall in the United States is about 20 to 25 inches and the maximum monthly rainfall about 71 inches,[9] considerably more than those recorded in China. This no doubt is due to the longer record which is to be obtained in the United States.

Along the southern coast in Hongkong and Pakhoi and their neighborhood more than half of the mean annual fall comes in the three summer months, June, July, and August. In central China, south of the Yangtze, the percentage for the same three months is smaller, about 40, while in the region north of Yellow River more than 60 per cent of the mean annual comes in these three months. This is of much importance to north China, since the rainfall in this part of the country is light—about 750 millimeters, or 30 inches—and as winter in north China is very cold. If a large portion of the precipitation should come in winter it would be in the form of snow, and hence be of little use to the farmers.

The percentages in the three winter months—December, January, and February—vary from 15 per cent in central China along the coast to about 1.5 per cent in Mukden. In northern China the precipitation in these three months all comes in the form of snow, while in central China the precipitation partly consists of rain. In the month of January, Pekin is a little colder than Boston. It has a monthly mean of 24°F., or 268.3°A., while in central China, Shanghai has a monthly mean of 37.2°F., or 276.1°A., in January. At Ningpo or even a little south we have snow every year, probably five or six times annually, while at Canton or Hongkong snow is rare.

[9] For some maximum daily and monthly rainfalls in the United States see McAdie's "Climatology of California," Washington, 1903. (Weather Bureau bulletin L), pp. 171-172.

AMERICAN DEFINITION OF "SLEET."

By CLEVELAND ABBE, Jr.

[Dated: Weather Bureau, June 30, 1916.]

In undertaking to collect and discuss American statistics of the occurrence and the amount of ice coating or "glaze" (a term just adopted for the coating) deposited on electric transmission and other lines, the Weather Bureau had forced on its attention the prevailing diversity in the use of the terms "sleet," "ice storm," "glazed frost," "silver thaw," "glare ice," etc. As the phenomena bearing these names are all more or less of public interest, it is very necessary that our names for them shall be clearly defined and as specific as possible in application. The chief difficulty met with seems to be the prevailing uses of the word "sleet"; accordingly, on January 6, 1916, the Chief of the Weather Bureau appointed a "committee to formulate suggestions of an appropriate nomenclature of sleet * * *."[1]

The committee thus appointed considered the subject from the five points of view: (1) Etymology of the word "sleet"; (2) early definitions; (3) modern definitions; (4) meteorological usage; (5) Weather Bureau usage. It will be convenient to discuss the committee's report in this manner.

1. ETYMOLOGY.

The word "sleet" is of uncertain derivation. Murray in the New English Dictionary, finds that it probably represents the Old English (Anglian) *slét* (which was phonetically derived from *sléatj*) and is related to the Middle Low German word *slôte* (LG. slôte, slate), Middle High German *slôze*, *slôz* and German *schlosse*, which mean "hail." Murray goes on to say that the Norwegian dialectal *sletta*, the Danish *slud*, and the Icelandic *slydda* have the sense of "sleet," but that it is difficult to associate any of these phonetically with the English word. (These Scandinavian words seem to mean "splash" or "slap"; and thus suggest the action which is repeatedly associated with *slét* in the early English authorities quoted by Murray. This significance will be recalled later in connection with usage.)

The committee sent out a large number of requests for information on this subject, but nothing in addition to the above derivations was received in reply.

[1] The members of the committee were Prof. H. C. Frankenfield (chairman), Prof. C. Fitzhugh Talman, Mr. P. C. Day, and Cleveland Abbe, jr.

2. EARLY DEFINITIONS.

A definition quoted by Murray's New English Dictionary and dating back to 1635 (Swan) says: "We have sometimes sleet; which is snow and rain together." This is the only explicit definition among the illustrations quoted by Murray under the noun.

The verb *to sleet* was defined as early as 1325 (?) as "now snow, now rain" (see Murray, 1, under the verb).

A similar meaning for the word *sleet* is implied under *sleetiness* in Bailey's Dictionary, v. 2, of 1727 and in Webster's of 1847.

We may, then, properly class Murray's definition under the present head and give it here, viz,

Sleet.—Snow which has been thawed by falling through an atmosphere of a temperature of a little above freezing point, usually accompanied by rain or snow.

However, there are some early American dictionaries which give different definitions. Thus the Royal Standard English Dictionary, fourth Brookfield edition, published at Brookfield, Mass., in 1809 defines "sleet" as "small snow or hail, rain and snow mixed together." In a dictionary [2] published at Burlington, N. J., in 1813 we find:

sleet (perhaps from the Danish "*slet*"). A kind of smooth or small hail or snow, not falling in flakes but in single particles.

In using the past participle as an adjective we find a popular transition to another interesting phenomenon. In 1849 Whittier wrote of winter "roaring through the sleeted pines" (quoted in Murray's New English Dictionary), and elsewhere is found the similar use "sleeted spars and frozen sails." Evidently "sleeted" means also covered with "sleet," which here stands for a coating of ice. American experience, at least, indicates that the icy coating of trees, spars, etc., rarely if ever results from a storm of "rain and snow mixed together." The present divergent usages were thus early foreshadowed.

3. MODERN DEFINITIONS.

In order to learn the present popular uses of the word *sleet* in the United States, the following letter was addressed to about 40 representative literary students, engineering organizations, electrical workers, and meteorologists:

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
OFFICE OF THE CHIEF,
Washington, D. C., March 11, 1916.

DEAR SIR: There has been some discussion in this Bureau as to the way in which the term "sleet" should be used for official purposes. A search of dictionaries and of a large amount of technical and non-technical literature appears to establish the following facts:

(1) In England "sleet" means usually, though not invariably, a mixture of raindrops and snowflakes.

(2) In this country the term "sleet" has nearly always been applied in meteorological literature to some form of water which is in a frozen state before reaching the ground, viz, either small particles of clear ice (often mingled with rain or snow) or little snowlike pellets, differing in structure from true hailstones, but often called "winter hail," or "soft hail." (In German the latter form of precipitation is commonly called Graupel, and this name is sometimes used in English texts. The French equivalent is grésil.)

(3) Non-meteorological usage in this country varies; comprising the uses noted above under (1) and (2), and also another, in accordance with which the term "sleet" is applied to a coating of ice on terrestrial objects formed by rain which freezes after contact with such objects. When this coating is heavy, and especially when it results in the breaking of branches, wires, etc., the phenomenon as a whole is often called an "ice storm." This use of the term "sleet" is common in the newspapers, and also in engineering literature, particularly in reference to accumulations of ice, due to rain, on wires and rails. In England the specific name of this form of ice is usually "glazed frost," and this term is used officially by the British Meteorological Office. The name "silver thaw" has also been applied to it in both Great Britain and the United States, but this expression is so inappropriate and misleading that it is avoided by most scientific writers.

The Bureau will feel indebted to you for any information you may be able to supply as to the use or uses of the term "sleet" current in your vicinity, and also as to the meaning which, in your experience, most commonly attaches to the term in contemporary speech and literature. Information would also be appreciated concerning the etymology and history of the word "sleet" in case you are able to add anything to what is found in the latest editions of the New English, Century, New International, and Standard Dictionaries.

A franked and addressed envelope is inclosed for your reply.

Very respectfully,

C. F. MARVIN,
Chief of Bureau.

The replies to this letter may be arranged into two general groups: (1) Technical wire-using industries, (2) literary and academic circles. The general tenor of the replies is fairly represented by the following selections (Nos. 1 to 12 and 24):

Wire-using industries.—Representatives of telephone, telegraph, and electric-power companies submitted replies represented by the following:

(1) DULUTH STREET RAILWAY CO.,
Duluth, Minn., April 14, 1916.

* * * The writer has always understood *sleet* to be water falling from the clouds and striking the earth in solidly frozen and compact drops, and has understood the difference between snow and sleet to be that the former is frozen in the form of flakes, while the latter is solidly frozen drops.

While I understand the above to be the general idea of *sleet*, it is true that the ice coating which forms on street railway trolley wires, when the wire is cold enough to freeze rain or mist coming into contact with it, is quite generally referred to as "sleet" on the wire. * * *

H. WARREN,
Vice President and General Manager.

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(2) "ELECTRICAL WORLD,"
New York, N. Y., March 15, 1916.

Answering your inquiry of March 11 concerning the definition of "sleet" as applied in this country, the expression is used throughout the electrical industry by operators of both electric-lighting plants and street-railway properties as referring to the condition of frozen rain or ice which *coats* line wires, trees, and other overhead objects. By a common opinion "sleet" refers to rain or snow which has fallen on cold objects and there congealed, forming an adherent coating.

O. H. CALDWELL,
Assistant Managing Editor.

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(3) "ELECTRIC RAILWAY JOURNAL,"
New York, N. Y., March 16, 1916.

* * * A very definite use of the term [sleet] has developed in the electric-railway industry. In this case it is applied to all coatings of ice on wires or rails which may be formed by rain that freezes as it falls or by small hailstones that adhere to cold objects; * * * and a number of devices have been introduced to remove the accumulations of ice from the overhead contacts or the third rails. These devices are invariably called "*sleet cutters.*"

My understanding of the term as used in the electric-railway industry is that it is applied to the accumulation of ice, rather than to the form of a precipitation that causes the ice. * * *

F. KINGSLEY,
Associate Editor.

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(4) WESTERN UNION TELEGRAPH CO.,
Washington, D. C., March 8, 1916.

The term "sleet" is used by this company and other wire-using companies in a sense somewhat different from the meaning generally given it by others. The term is applied by us to a cold rain that freezes on striking the ground, poles, and wires, forming a transparent icy coating.

So far as we know, there is no term that applies to this particular form of precipitation, which, on account of the great damage to pole lines and wires that so frequently results from the ice loads, is of tremendous importance to the public, not only because of interrupted telegraph and

[2] New critical pronouncing dictionary of the English language, by an American Gentleman. Burlington, N. J. 1813.

telephone service, but also because of the effect on railroad service when dispatching circuits and automatic signal systems fail.

For the consideration of the Weather Bureau, it might be suggested that it would be of great practical benefit to distinguish between this form of precipitation—or condition of the weather—and ordinary rain or snow. This distinction would be more beneficial than that now made between snow and the peculiar icy pellets which others now call sleet. It would be of great value, it seems to us, to have weather reports take this peculiar weather condition into account, and a convenient name might be devised for it in order to avoid present conflicting usage of the term "sleet."

GENERAL SUPERINTENDENT OF PLANT
(Through H. F. TAFF, *Manager*).

It appears from these selections that the industries represented by them habitually call the ice coating formed by cold rain, or snow, or rain and snow combined, or even "small hailstones," by the name of "sleet." It is evident, however, that some, if not all, recognize another meaning for "sleet," viz, precipitation in the form of "solidly frozen drops" (Nos. 1 and 4). One letter (No. 4) specifically points out the need for "a convenient name * * * to avoid present conflicting usage."

A recent personal canvas among some prominent electrical engineers by one member of the committee, also elicited the above definition of "sleet." When asked to give a name for the ice pellets falling as such and not clinging to the wires or other objects, none was able to do so. After discussion, however, all readily admitted that their use of "sleet" (as reflected in letters 2, 3, and 4) was not technically correct, and the majority expressed entire willingness to accept in place of "sleet storm" the term "ice storm" for use by the Weather Bureau, as they would understand exactly what was meant.

Literary and academic usages.—The following selections from replies submitted by writers, instructors, and others show diverse usages in other than technical circles.

(5) HARVARD UNIVERSITY,
Cambridge, Mass., March 15, 1916.

It is my impression that the popular usage of the term "sleet" in this vicinity is with reference to a mixture of snow and rain, or wet snow. I have also heard it used, though less frequently, for what I call an ice storm, i. e., a coating of ice on terrestrial objects. I myself prefer the English use of "sleet" for snow and rain; "soft hail" for the snow pellets; "frozen rain" for what popular usage designates as hail, but which, occurring in winter, is really frozen rain drops without the concentric structure or origin of hail. * * *

ROBERT DEC. WARD,
Professor of Climatology.

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(6) WEATHER BUREAU,
Boston, Mass., March 22, 1916.

* * * The term "ice storm" seems to be generally understood by the public and press in this vicinity as meaning an accumulation of ice on objects by the freezing of rain on them and not a fall of *frozen* rain. * * *

J. W. SMITH,
District Forecaster.

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(7) WEATHER BUREAU,
Ithaca, N. Y., March 17, 1916.

* * * It would seem that the term "sleet" might well be defined as in paragraph 2 of your letter [above, p. 282]. I think it very desirable to add to our meteorological vocabulary an expression to indicate the conditions when accumulations of ice occur on wires and other objects. It would seem that "ice storm" is an appropriate expression and has the advantage of being already in use. It is a better expression than "sleet storm," because a heavy fall of sleet may occur without any such accumulation, or ice may form on wires and the like when the precipitation is wholly in the form of rain.

WILFORD M. WILSON,
Professor of Meteorology.

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(8) HARVARD UNIVERSITY,
Cambridge, Mass., March 16, 1916.

To me the word "sleet" has the meaning which you put under No. 2 [above, p. 282], i. e., "either small particles of clear ice (often mingled with rain or snow), or little snow-like pellets, etc." This meaning I recognize as the most familiar to me if an exact definition is to be given, though the sense No. 1 ("a mixture of raindrops and snowflakes") would not surprise me, and I might use, on occasion, the word in that sense myself. * * * I am not familiar with the terms "winter hail," "soft hail," "ice storm," "glazed frost," "silver thaw."

EDWARD STEVENS SHELDON,
Professor of Romance Philology.

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(9) WEATHER BUREAU,
Portland, Oreg., March 27, 1916.

Conversation with newspaper men and others on the subject [of sleet] brought out the fact that there is little difference of opinion in this section of the country as to the meaning of the word [sleet]. * * *

To sum the matter up, sleet consists of small pellets of ice which fall in winter; rain which falls along with sleet is not included in the term, but is separately mentioned; raindrops unfrozen until they reach the ground, but which freeze immediately after coming in contact with terrestrial objects, are, nevertheless, raindrops, but the whole phenomenon is called a "silver thaw." * * * [Mentioned in paragraph 3 of the circular letter, p. 282.]

FLOYD D. YOUNG,
Assistant Observer,

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(10) METEOROLOGICAL OFFICE,
Toronto, Canada, April 6, 1916.

Your statements regarding the use of the term [sleet] in the United States cover most perfectly its use by the public and press in Canada, and I do not think I can add anything useful. Our newspapers frequently speak of rain freezing as it falls as a "sleet storm," and the terms "silver thaw" and "glazed frost" are practically unknown outside meteorological reports. * * * [Compare No. 24.]

R. F. STUPART,
Director.

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(11) *New York, N. Y., March 18, 1916.*

I regret to say that I can not supply you with anything of value in regard to the use of the word "sleet."

All I can do is to say that I myself have been in the habit of using the word to indicate wind-driven drops of semifrozen rain.

BRANDER MATTHEWS.

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(12) UNIVERSITY OF VIRGINIA,
University, Va., March 14, 1916.

I can add nothing to the etymology or history of the word "sleet" beyond what is found in the dictionaries mentioned. Let me suggest, however, as to meaning, that *nothing is sleet that does not rattle on a tin roof or against the window pane.* It seems to me that the element of sound is what differentiates "sleet" from its winter congeners. If you will investigate the occurrence of the word in modern literature (see concordances to Bible, Shakespeare, Tennyson, Wordsworth, etc.), my impression is that you will find its chief differential lies in its noise-making property. This is my instinctive feeling about the word and corresponds, I think, to the current acceptation.

C. ALPHONSO SMITH,
E. A. Poe School of English.

These selections (5) to (12) show that among those most accustomed to use words carefully, viz, writers and students of language, the term "sleet" is primarily applied to some form of precipitation while it is still in the air rather than to any deposit on the ground or other objects (Cf. nos. 5, 7, 8, 11, 12). This stands out at once in marked contrast to the usage, more or less popular but by no means universal (Nos. 4, 6, 9), that applies the term to the coating of ice sometimes formed during cold rains.

These replies strongly suggest the reflection that the name "sleet" is being transferred from its original meaning of a form of falling precipitation, to an ice coating. This tendency is perhaps developing because it is carelessly concluded that the coating is the result of the falling of the icy or snowy pellets which are the original "sleet." It is an easy transition in the popular, non-meteorological mind, from "sleeted spars" through "sleety" spars to spars covered with "sleet."

The popular conclusion is wrong. Though associated there is no genetic relation between what is more properly called "sleet" and the ice coating of the glazed, icy spars.

The committee find it specially significant that several of the weightier communications emphasize the characteristic of "sleet" being wind-driven, semifrozen drops such as would rattle on a roof or against a window pane (Nos. 11, 12). Evidently some of our people still hear in the word "sleet" the suggestion of the slapping, splashing, or rattling sounds and sensations which Murray and others find to be related to the old English word *slēt*.

4. METEOROLOGICAL USAGES.

The following quotations will serve to show how meteorologists and those professedly writing on meteorological subjects, have defined *sleet*.

Unofficial publications.—

(13) I have little to say of [rain, snow, and hail], three modes of the resolution of the nimbus, which has not been already treated of by meteorologists, nor of their compound, commonly called sleet.—*Thos. Forster* "Researches about atmospheric phenomena." 2d ed., London, 1815. p. 83.

(14) In this case, precipitated moisture descending in the frozen form of flakes of snow, begins to melt so soon as it reaches those atmospheric strata, the temperature of which is above the freezing point. In such circumstances the snow, by the time it reaches the surface of the earth, is partially melted; and has received the name of sleet.—*Graham Hutchison* "A treatise on the causes and principles of meteorological phenomena." Glasgow, 1835. p. 215.

(14A) *Hail.*—* * * Three species of hail, founded on the different sizes of the hailstones, are generally distinguished.

* * * Very small hailstones are termed *sleet* [Graupeln, Riesel, grésil in French]. Generally spherical, or almost spherical, they rarely attain a diameter of 2 millimeters; though they may reach 3 or even 4. Isolated hailstones [Die einzelnen Körner] are opaque, frequently soft, and of a whiteness approaching that of snow. The largest are sometimes surrounded with a slight film of ice; they fall in winter and in spring during gusty weather; they rarely accompany storms [selten von Gewittern begleitet]. pp. 375, 376.

* * * *Formation of sleet* [*Entstehung der Graupeln.*].—This is more easily explained because it is more commonly observed in the cold season. * * * p. 387.—*C. V. Walker*, translation (1845) of *Ch. Martins* annotated French version (1843) of *Ludwig Friedrich Kämtz*, "Vorlesungen über Meteorologie." Halle, 1840.

(NOTE.—Words in [ ] are from the original German version; note that the English translation employs *sleet* for the French *grésil* which Martins used as the equivalent of the German *Graupeln*. In another passage (Walker, p. 379; Kämtz, p. 450) we find the English *sleet* used for the French *giboulées* and the German *Graupeln* when referring to these Graupeln-like falls in France during the spring.—C. A. jr.)

(15) [Hail] is different from sleet, which is nothing more than frozen rain and occurs only in cold weather.—*John Brocklesby* "Elements of meteorology." 3d ed., New York, 1849. p. 122.

(16) Sleet is the mixture of rain and snow or small hail occurring during variable and gusty weather.—*David Purdie Thomson* "Introduction to meteorology." Edinburgh, 1849. p. 199.

(17) Sleet appears to be formed from snowflakes falling through a stratum of moist air at a temperature of 32°F. or higher. The size of the flakes is caused by the snow coming against each other and uniting by regelation, and they are no doubt further increased by the condensation of vapour on their surfaces as they float down through the moist air. Sleet falls chiefly in winter and spring and is very rarely an accompaniment of storms.—*Alex. Buchan* "Handy book of meteorology." Edinburgh, 1867. pp. 123, 124.

(18) The fine, soft hail seen in autumn and winter particularly, the surface of which looks as though powdered with flour, is usually called *sleet*. It is, properly speaking, a kind of middle formation between hail and snow.—*Wm. Lackland* "Meteors, aërolites, storms, and atmospheric phenomena, Tr. from the French of Zürcher & Margollé." New York, 1871. p. 83.

(19) Sleet is a mixture of snow and rain.—*R. H. Scott* "Elementary meteorology." 3d ed., London, 1887. p. 143.

These selections show that from 1815 on there have been various conceptions of "sleet" among meteorologists. We find it defined as—

(*a*) A mixture of rain, snow, and hail (see 13, 16).
(*b*) A mixture of rain and snow (see 19).
(*c*) Partially melted snow (see 14, 17).
(*d*) Frozen rain, differing from hail (see 15).
(*e*) Fine, soft hail, which seems to be powdered with flour (see 14A and 18).

The definition by R. H. Scott (No. 19), while given in an unofficial publication, probably carries the most authority among the above quotations. The author was in charge of the British Meteorological Office when he wrote this definition. It is not fundamentally divergent from Nos. 16 or 17, and agrees with the old English definition given by Murray (see p. 282).

It is notable that the American author quoted (No. 15) has a divergent definition, see (*d*), above, which reappears in letters 1, 8, 9, 11, 12, quoted on pages 282–3. Lackland's translation of Zürcher and Margollé (No. 18) offers a definition (*e*) which may rest upon the shoulders of his dictionary maker (compare, however, 14A and its note). At any rate it furnishes occasion to quote (20) an official American author writing privately but under strong official influences (italics ours):

(20) There is a kind of soft hail, rounded pellets, and of very soft grain, which falls in winter or spring. This seems to be rather frozen *sleet*, which *itself is* a mixture of snow and rain, rather than true hail. A distinction is made between this soft hail, as it is called, and true hard hail, by meteorologists abroad; in the United States this distinction is not always made.—*A. W. Greely* "American weather." New York, 1888. p. 78.

This passage from Greely shows that also American usage confused the English word "sleet" with the phenomenon of what is sometimes called "soft hail" (*Fr.* grésil; *Ger.* Graupel). Greely, however, adheres to the English definition of sleet as a mixture of snow and rain; this is all the more interesting in view of the following official definitions.

Official publications.—Among the early official instructions to meteorological observers in America, stands the work prepared in 1850 by Prof. Arnold H. Guyot at Cambridge, Mass., and issued by the Smithsonian Institution.[3] It contains the following definitions and instructions:

(21) *Sleet*, which consists in small balls of snow, white and opaque, commonly without a crust of ice, like the opaque nucleus found within hailstones, falling more frequently in spring and in autumn.

Frozen rain drops should be distinquished from the preceding forms; they make little balls of transparent ice.—*Directions* for meteorological observations. * * * Smithsonian Institution, Washington, 1870. p. 31.

The Smithsonian Instructions, from which (21) is quoted, had been in use since 1850, and became the prescribed reference work for the observer sergeants of the Signal Service, U. S. A., when that service began meteorological work in 1870.[4] It is not at present ascertainable how long this definition of sleet prevailed in the Signal Service. The following quotation shows that it was still prescribed, at least for voluntary observers, as late as 1882.

(22) There will also be noted:

Sleet, which consists in small balls of snow, white and opaque, commonly without a crust of ice, like the opaque nucleus found within hailstones, falling more frequently in spring and in autumn.

Frozen rain drops should be distinguished from the preceding forms; they make little balls of transparent ice.—*Instructions* for voluntary observers of the Signal Service, U. S. A. Washington, 1882. p. 87.

[3] *Smithsonian* miscellaneous collections. (19). Directions for meteorological observations and the registry of periodical phenomena. Washington, Smithsonian Institution 1870. p. l., 70 p. 8°. (Reprinted with additions, from the original edition, Washington, May 1, 1850. 40 p.)

Arnold Henry Guyot, author of the above instructions, was born in Switzerland in 1807, educated at Neuchâtel and German universities; he came to the United States in 1848, in 1849 delivered lectures in French on Physical Geography, and in 1850 prepared these instructions (probably in English) for Joseph Henry, Secretary of the Smithsonian Institution. Selection 14A above, shows that his use of sleet conformed to good contemporary English usage.

[4] *See* Annual Report of the Chief Signal Officer for 1870. Washington, 1870. p. 22, Paper 2, paragraph II; *and also* Same, for the fiscal year ended June 30, 1871. Washington, 1871. p. 79, Paper 4, paragraph 37.

The present definition of sleet has been in force in the Weather Bureau since about 1897. The Bureau's "Instructions for preparing meteorological forms" states it as follows, in paragraph 119:

(23) Care should be taken in determining the character or precipitation when in the form of sleet or hail. Only the precipitation that occurs in the form of frozen or partly frozen rain should be called *sleet*. * * * It frequently happens that snow falls in the form of small round pellets, which are opaque, having the same appearance as snow when packed. This should never be recorded as sleet.—*Weather Bureau* "Instructions for preparing meteorological forms." Washington, 1913. Paragraph 119.

The director of the Canadian Meteorological Office advises this Bureau, under date of April 6, 1916, as follows:

(24) In the Book of Instructions issued to Canadian observers, occur the following definitions of certain terms which have a bearing on the subject (sleet):

Graupel, denoted by △. The stones are small, like snow pellets, without crystalline structure. When mixed with rain it often bears the name of "sleet."

Silver thaw is the phenomenon of frozen moisture on trees or other objects when the weather suddenly becomes warm after great cold.

Glazed frost. This term is applied to the glazed surface formed on the ground, trees, and other objects by rain falling and immediately freezing thereon. It differs from the "silver thaw" in this respect, that the latter is formed by the condensation of vapor, and consequently has not the same smooth surface.

The British Meteorological Office, however, publishes the following:

(25) * * * No separate letter is given for sleet; the combination **rs** [i. e. rain and snow] is generally used.—*Meteorological Office* "The Observer's Handbook." Annual edition 1913. London, 1913. p. 52.

This definition adheres to the earliest English meanings quoted by Murray; but we see the Canadian definition (24) departing from it and tending toward the early American concepts given on p. 284 and in quotation (21).

Among the Weather Bureau publications the usage has been officially controlled by the "instructions" quoted under (21), (22), and (23). Nevertheless many lapses into the popular confusion of names have occurred. The following will serve to illustrate variations in Weather Bureau usage:

(26) The sleet storm of the 24th (at Vevay, Ind.) covered all exposed objects with a heavy coat of ice and many trees were broken.—*Monthly Weather Review*, March, 1888, p. 671.

(27) At Kansas City, Mo., a severe sleet storm occurred on the 26th, wires became thickly coated with ice; [and in Iowa] telegraph lines were covered with sleet.—*Monthly Weather Review*, December, 1888, p. 309.

(28) Sleet is a winter phenomenon; it is made up of small transparent drops of ice, apparently formed by the freezing of raindrops as they fall through the lower cold air.—*J. Warren Smith* quoted in Monthly Weather Review, October, 1898, p. 470.

(29) The heavy storm of snow, sleet, hail, and wind [did much damage] March 11 and 12 * * * the sleet was of bird-shot size, which melted as it fell and then crusted between the rails.—*Monthly Weather Review*, April, 1901, p. 175.

(30) The sleet storm in northern New York * * * [was due to] rain which froze upon contact with solid objects.—*Bennett* in Monthly Weather Review, March, 1913, p. 372–3.

However, some semiofficial publications by Weather Bureau men carefully maintain the distinction between "sleet," "snow and rain," "ice storm," and the glaze or ice coating (Glatteis). The following passage from a recent work by Weather Bureau officials is one of these instances where the best Weather Bureau usage is clearly presented:

(31) *Heavy and damaging storms of snow, sleet, and ice.*—It is desired in this connection to make some reference to the most damaging storms of snow, sleet, and ice. Sleet invariably falls in connection with snow or rain, or both, and ice storms are commonly confused with sleet storms. Sleet is frozen rain; ice storms are occasioned by rain freezing upon objects with which it comes in contact. In the former the freezing occurs before the drops strike the earth; in the [ice storms] the cold surfaces upon which the rain falls freeze the water into a coating of ice.—*Cox & Armington* "Weather and climate of Chicago." Chicago, 1914. p. 224.

CONCLUSION.

1. The fundamental confusion of usage in the United States seems to arise from applying the same name, "sleet," to two forms of frozen precipitation, one of which is frozen in the free air and the other after contact with terrestrial objects. It is interesting to note that the official terms of all other countries distinguish between and apply distinctive names to these two conditions of the hydrometeor.

The U. S. Weather Bureau, following the earlier Signal Service and Smithsonian practices, also has distinguished between these two conditions. It is evident from the preceding that a considerable portion of the public also feel the need for making such a distinction; and the Weather Bureau is of the opinion that science is better served by maintaining such a distinction rather than by broadening the scope of the term. It is therefore recommended that the term "sleet" be restricted to *one* form of precipitation.

2. As has been sufficiently pointed out, the present British definition of "sleet" as mingled snow and rain, now used in official British literature, does not appear to have been adopted by any other nation; and it is not in accord with definitions by some English writers. Strange to say, it is also out of accord with the French definition of the French word "grésil," which dictionaries published in England give as the French equivalent of the English word "sleet."

In view of the above the Weather Bureau finds that it is not justified in changing the present Weather Bureau definition of "sleet." The Weather Bureau therefore adheres to its definition which has been in force since about 1897, viz:

Only the precipitation that occurs in the form of frozen or partly frozen rain should be called sleet. (See selection No. 23.)

The present official Weather Bureau definition of *sleet*, here reaffirmed, is understood to apply to the same phenomenon which German meteorologists call "Eiskörner" (ice grains) and to exclude those forms of precipitation which the English call "soft hail" (*Ger.* Graupel, *Fr.* grésil) and "glazed frost" (*Ger.* Glatteis, *Fr.* verglas).

3. The Weather Bureau recognizes the need for a convenient name for the coat of ice that forms chiefly by the freezing of cold rain when it strikes cold objects or the earth's surface. As pointed out on p. 283, it seems clear that the name "sleet" is not properly to be applied to this ice coating; and the wire-using industries, who are the chief users of "sleet" in this manner, have expressed their willingness to adopt another and more logical term.

Certain publications have employed the name "ice storm" in such a manner that this term seems to be used as the name for the ice coating. This usage is not approved. The Weather Bureau holds that a term including the word "storm" should be applied to the general weather conditions producing certain effects, and not to the actual effects (ice coating, flooding, etc.) due to the stormy weather.

The English name for this ice coating, "glazed frost," has indeed the sanction of the British Meteorological Office, and also of the International Meteorological Organization,[5] as the English name for the phenomenon

[5] Codex of Resolutions adopted at International Meteorological Meetings, 1872–1907. * * * English edition. London, 1909. (M. O. No. 200.) p. 25.

called *Glatteis* in German and *verglas* in French; but it appears to be unfamiliar to the America npublic, including Canada. (See Nos. 10 and 24.) Furthermore, to the American the word "frost"—either alone or in composition—is more closely associated with the phenomenon of hoarfrost or sublimated water vapor than it is with ice or with temperatures below the freezing point of water. The Weather Bureau therefore rejects this name for the ice coating resulting from an ice storm and proposes to adopt the name "glaze" for the ice coating which forms when cold rain comes in contact with strongly chilled terrestrial objects.

This use of "glaze" has already been recognized as occurring in the United States; it is, in fact, the fourth meaning under that word as given in Murray's New English Dictionary, and we there find the following illustration:

(32) 1796. *Morse*, American Geography, v. 1, p. 215: Whenever the winter * * * sets in with rain, so as to cover the branches and leaves of trees with a glaze of ice.

The term "glaze" is accordingly adopted as the official Weather Bureau equivalent of the English term "glazed frost," the French "verglas," and the German "Glatteis."[6] The Bureau would not exclude from the pages of its publications, however, these other equivalent expressions when used by other than Weather Bureau writers.

RIME (RAUHFROST, DUFT, GIVRE).

In the course of the above discussion regarding American terminology, resulting in the adoption of "glaze," an old American name, for the English "glazed frost" (Glatteis, verglas), the Weather Bureau has also had to consider the phenomenon called "rime" (Rauhreif, givre). It is here desired to call the attention of the American student to the following statement taken from the Observer's Handbook published by the Meteorological Office, London:[7]

Rime. V. The international symbol V is intended to represent the phenomenon denoted by the German words *Rauhreif*, *Rauhfrost*, *Anreim*, *Duft*, and the French *givre*. Silver Thaw has been used as the English equivalent of these terms by some writers; others, however, use this expression to translate the German "Glatteis," French "verglas." It is here proposed to use the word rime to translate the German "Duft," French "givre."

Rime, as thus defined, is an accumulation of frozen moisture on trees, etc., which presents a silvery white and **rough** surface, bearing some resemblance to hoarfrost; it is, however, **only formed during fog,** whereas hoarfrost is a result of nocturnal radiation from the earth to a clear sky.

In our [i. e., England's] climate rime is of comparatively rare occurrence, for the white deposit on grass, etc., observed on foggy mornings consists in most cases of hoarfrost which had formed before fog developed. On Ben Nevis the depositions, however, were frequently so thick that they greatly interfered with the work of observing by clogging up the louvers of the thermometer shelter, etc. The phenomenon was noted in the record under the name "fog crystals."

The particles in a fog, even at temperatures far below the freezing point, consist of droplets of undercooled water, and when these come in contact with bodies they solidify immediately and form rime. Hoarfrost and rime may be distinguished, to a certain extent, by the fact that the former is not readily formed on good conductors of heat in thermal contact with relatively warm bodies on which they can draw for a supply of heat to replace that lost by radiation, whereas rime is deposited on all with equal facility.

The Weather Bureau at present feels that no addition is necessary to this statement, and wishes to record its official adoption of *rime*, as defined above, into the Weather Bureau vocabulary.

The phenomenon of rime is not uncommon in the United States, although rare at lower altitudes in our temperate districts. For example, at the Weather Bureau station on the Blue Ridge near Bluemont, Va., Mount Weather standing at an altitude of about 1,725 feet above M. S. L., rime was observed and photographed several times during the period 1903–1913. Pennants of "fog crystals," as we used to call the rime, would form to a length of many inches during driving cloud (fog) in cold weather (March). A very modest example of this Mount Weather rime is published in Fassig's "Climate and Weather of Baltimore" (Maryland Weather Service, v. 2), as Plate XXI, and its formation described on page 413 of that work. Plate XXII of the same work also illustrates the development of *glaze* (Glatteis) at the same locality. The rime is there called "frost figures." The frost-like deposit reported from Buffalo, N. Y., by Mr. Cuthbertson in the MONTHLY WEATHER REVIEW, March, 1902, **30**:125–6, seems to have been a most interesting case of the formation of rime in quiet, fog-filled air (it was there called "hoarfrost," the name by which it was then known in the Weather Bureau).

TWO ABNORMAL PRESSURE DISTRIBUTIONS IN ITALY.

Prof. Filippo Eredia, of the Ufficio Centrale di Meteorologia e di Geodinamica at Rome, submits the two isobaric charts presented in figures 1 and 3, with the statement that they are of interest not only because of the regularity in the pressure distribution but also because they represent, respectively, the highest and the lowest barometric pressures over Italy as shown by the Italian daily weather maps (Bollettino dell' Ufficio Centrale). The accompanying weather and sea conditions are presented in figures 2 and 4, which also repeat the isobars for 5-millimeter intervals.

Prof. Eredia writes that every day before drawing the isobars on the daily charts he subjects the individual reports to a minute examination and to comparisons between neighboring stations, giving particular attention to the barometric observations. In this scrutiny he finds his direct knowledge of the various stations, as well as the employment of special reports, of great value in determining the reliability of the individual daily reports; furthermore, he carefully checks the latter against the 24-hour changes at neighboring stations. It thus occurs that the barometric observations, as published for some cities in the Bollettino, do not always agree with the positions of the more carefully adjusted isobars of the corresponding map. Thus the pressures reported by Nice (Nizza) are often out of accord with the values at neighboring stations. In such cases the Nice pressure is rejected, as was done in drawing the isobars for January 24, 1907 (fig. 1).

The localities forming the Italian reporting réseau for the daily map, and therefore used for forecasting, are all at medium altitudes, so that the sea-level reductions of the barometers are perfectly comparable among themselves. For some years the Italian service has been making use of daily pilot-balloon observations at various stations. It is hoped to present an account of this pilot-balloon service in a later issue.—C. A. jr.

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[6] *See* the English edition of the Codex, cited in footnote 5. *Also* Internationaler Meteorologischer Kodex * * * bearbeitet von G. Hellmann & H. H. Hildebrandsson. Deutsche Originalausgabe, 2te vermehrte Aufl., Berlin, 1911. (Veröffentl. d. k. preuss. meteorol. Instituts. Nr. 242.) p. 19.

[7] *Great Britain. Meteorological Office.* The Observer's Handbook. * * * Annual edition, 1913. London, 1913. (M. O. 191. For official use.) p. 55.

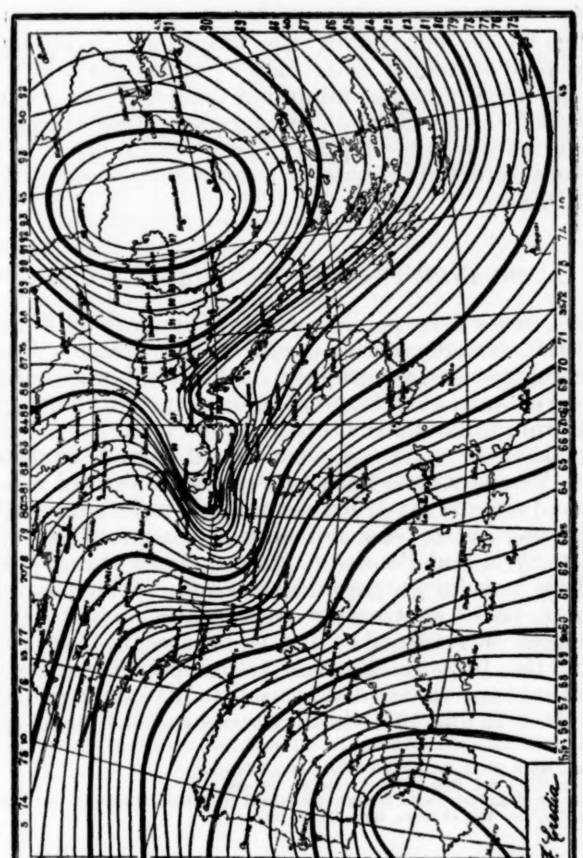

FIG. 1.—Extraordinary anticyclone of Jan. 24, 1907, over southeastern Europe. (Isobars for whole centimeters.)

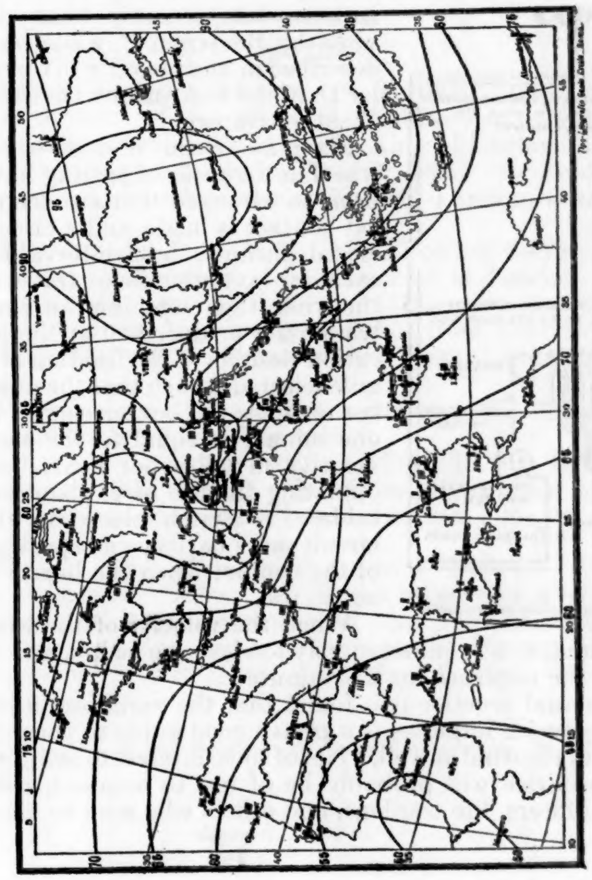

FIG. 2.—State of sky, wind direction and velocity, and state of the sea, accompanying the anticyclone of Jan. 24, 1907. (Isobars for each 5 centimeters.) (For meaning of symbols see p. 273.)

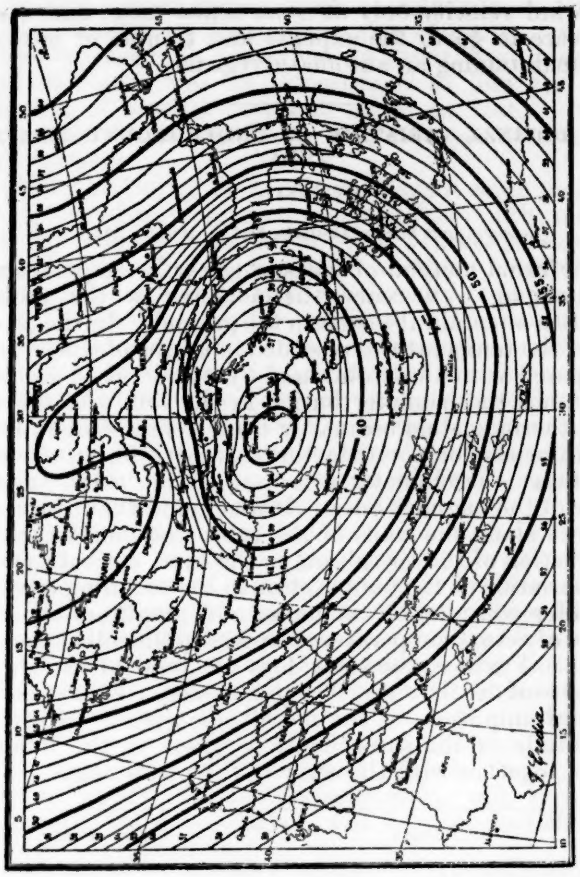

FIG. 3.—Extraordinary cyclone over the Tyrrhenian Sea, Jan. 23, 1915. (Isobars for whole centimeters.)

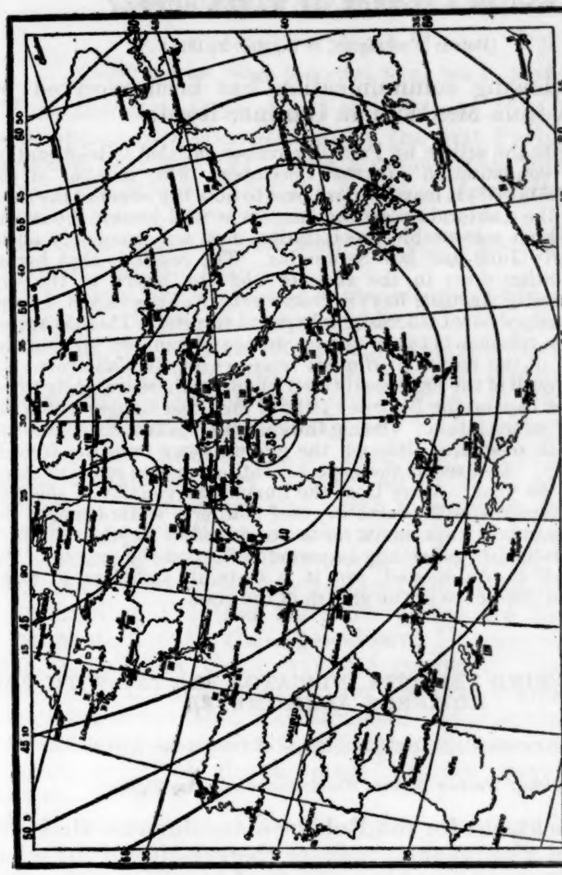

FIG. 4.—State of sky, wind direction and velocity, and the state of the sea, accompanying the cyclone of Jan. 23, 1915. (Isobars for each 5 centimeters.) (For meaning of symbols see p. 273.)

FOG AS A SOURCE OF WATER SUPPLY.

[Dated: Washington, D. C., Mar. 20, 1916.]

The following communication has been received by the editor from Mr. William Gardner Reed:

Referring to the article by Paul Descombes entitled "Reforestation and occult condensation" in the December, 1915, number of the REVIEW (**43**:617-618) it may be of interest to note the effect of the summer fogs of the California coast region. As is well known the region is one in which measurable precipitation does not commonly occur between early June and late September. The result is that herbaceous vegetation dries in the summer and the brown of the dry grass (practically standing hay) is characteristic of the region, except where the surface cover is forest or chaparral (brush). There is apparently a close relation between the occurence of summer fog and the distribution of the redwood (*Sequoia sempervirens*) in California. In addition, a result of the fog is easily seen wherever there are single trees, such as is the case on the Berkeley Hills of the Coast Ranges which are in process of reforestation. During the summer fogs the small trees are dripping with moisture, although the ground away from the trees is perfectly dry. As a result the grass beneath each tree remains green throughout the year. Away from the immediate vicinity of the tree the grass is brown and the earth dry and powdery, while beneath the tree the ground is kept moist to a considerable depth. * * * Whether this moisture has any important effect on the growth of the tree may well be questioned, but it is certainly sufficient to make an important difference in the growth of the grass.

A SIMPLE WIND VELOCITY INDICATOR FOR USE WITH THE ROBINSON ANEMOMETER.

By BENJAMIN C. KADEL, in charge of Instrument Division.

[Dated: Weather Bureau, Washington, D. C., May 27, 1916.]

An attachment for the Robinson anemometer that will indicate in a convenient manner the velocity of the wind when desired, without the expense of installing and maintaining a continuously operating register, has recently been devised by Benjamin C. Kadel and described in an appendix to Circular D, of the Instrument Division, Weather Bureau.

FIG. 1.—Plan of circuits for the Kadel indicating anemometer.

Six pins on the first or worm wheel in the train of gearing have been so arranged that an electrical contact is made and a circuit closed during a brief interval for each one-sixtieth mile of travel of the wind, thus sounding an electric buzzer or door bell at the location desired. The fraction of a mile selected is such that the number of times the buzzer sounds in one minute is equal to the wind velocity in miles per hour, thus obviating the use of explanatory tables. A switch placed in the circuit saves battery and sparking of the contact when the buzzer is not in use.

When the velocity of the wind is desired, it is required merely to close the switch and to count the impulses for one minute.

In actual practice it is found that the variation in the time between impulses is a pretty good guide to the gustiness of the wind as well, a fact of some interest to aviators.

The device will probably be of use to aviators, rifle-range officers, fire wardens, and others who wish to know the wind velocity only at a particular time, and who do not care to go to the expense and trouble of providing and maintaining an automatic register.

THE DIURNAL VARIATION OF UNDERGROUND TEMPERATURE.[1]

By S. SATO.

[*Reprinted from* Science Abstracts, Sect. A, Mar. 25, 1916, § 287.]

The usual method of measuring earth temperatures is by hanging a mercury thermometer at the required depth in a metal tube sunk in the ground. In the present paper the temperatures recorded in a tube of this type are compared with those obtained by means of an electrical resistance thermometer buried in the soil. As the mercury thermometers ordinarily used were not of sufficient sensitiveness for a satisfactory comparison, an electrical resistance thermometer was used in the earth tubes in place of the mercury ones. It was found that conduction of heat along the walls of the tube, and conduction and convection of the air column in the tube, caused the diurnal variation of the temperature in the metal pipe system, to differ considerably in phase and amplitude from the curve of actual temperature changes in the soil at the same depth. Further, the error does not tend to vanish with increase of depth, but rather to increase. The ratio of the diurnal amplitude in the metal pipe system to the true amplitude at the same depth is given in the following table, together with the error in the phase angle:

Depth.	30 cm.	40 cm.	50 cm.
Ratio of amplitudes	1.88	2.18	2.62
Phase difference, in hours	7.5	10.25	13.5

Thus at 50 cm. depth the amplitude given by the metal pipe system is more than $2\frac{1}{2}$ times the true value, and the maximum and minimum temperatures occur $13\frac{1}{2}$ hours before the times of the corresponding extremes in the soil at the same depth. The absolute error in temperature commonly ranges up to between 0.5 and 1.0° C.—*J. S. Di*[*nes*].

ALEKSANDR IVANOVICH VOEĬKOV, 1842-1916.

The Novoe Vremîa (Petrograd) of January 30/February 12, 1916, announces the death of the eminent Russian meteorologist and geographer, Aleksandr Ivanovich Voeĭkov (Woeikof), at Petrograd on January 28/February 10, 1916, from inflammation of the lungs.[2]

Voeĭkov, or, as he was accustomed to transliterate his name, Woeikow, was born in Moscow in 1842 of a family that had already given Russia a number of writers. While still young he traveled not only in western Europe, but also in Syria and Palestine, and no doubt thereby developed his love for geographical studies. After passing his student years at German universities, particularly at Göttingen, he returned to Russia, became, in 1866, a member of the Imperial Russian Geographical Society, and from that time on devoted himself to meteorological studies. In 1873 and 1875 these researches led him to travel,

[1] Proc., Math. phys. soc., Tokyo, Dec., 1915, 8:328-336.
Tohoku Univ. Sci. Rep. 4, No. 5, 1916, pp. 393-405.

[2] Note by Semenov Tian-Chanskiĭ, abstracted by Émile Haumont, *in* Annales de Géographie, No. 134, 15 mars, 1916, 25:150-151.

first, to the United States, then to Mexico and Yucatan, and, finally, to South American countries. Each of these voyages he undertook without any governmental aid; each was an opportunity to him for the acquisition of several new languages; in fact, it was incomprehensible to him how a language could be difficult for anyone.

While in the United States Voeĭkov spent some time in Washington, where he made the acquaintance of the members of the recently organized national weather service, of Joseph Henry, and other scientific leaders. In 1882 he qualified as privat-docent at the University of St. Petersburg. Two years later he published his great work, "The Climates of the World," which brought him universal renown as soon as its translation into German, in 1887, made it available to the European scientific world. An English translation of this work from the Russian was at once prepared by Dr. Alexander Ziwet (Ann Arbor) under the encouragement and supervision of Prof. Cleveland Abbe, and revised by Voeĭkov in 1900, but no publisher has yet been found for the work. In 1885 he was appointed professor of physical geography at his university and, later, director of the meteorological observatory there. This permanent appointment to a professorship marked the beginning of a new series of publications, which at first revealed the meteorologist and then the ideal geographer. As examples, one may cite his study, in 1904, on the rôle of the Pacific Ocean in the world's affairs, a very remarkable article in the Novoe Vremia on the regeneration of Russia, and a French work, "Le Turkestan russe." Somewhat against his will, Voeĭkov had come to be a vegetarian, and he also contributed studies on vegetarianism.

Among his meteorological papers, those appearing in the Meteorologische Zeitschrift have had the most interest for American students; but they have numbered more than 100, and it is not necessary to give a full list of his works here. Many of them, perhaps some of the most important, deal with the relations between the temperatures of air, ground, oceans, and lakes. His meteorological work finally culminated in his handbook, "Meteorologia," a work of 719 pages, published in Russian in 1904, and the present leading meteorological text in that language.[3]

He had been one of the editors, and certainly the leading contributor to "Meteorologicheskiĭ Viestnik," the meteorological monthly published by the Imperial Geographical Society. His many communications to geographical journals of various countries on most diverse subjects indicate the extent of his knowledge and the originality of his perception. The readers of the REVIEW will recall a number of his contributions to these pages.

His Russian biographer remarks that, in his private life as in his scientific career, Voeĭkov always showed a rare degree of modesty and was thoroughly unselfish. Very simple, almost Spartan in his tastes, he closely resembled his friend, the celebrated Russian chemist, Mendelief. While we did not all have an opportunity to enjoy the simplicity of his greeting, the rarity of his free and lively spirit, or the singular charm of his conversation, certainly we may join his French friends in regret at the loss of an illustrious scientist.

[3] See notice of this work by *S. Hanzlik* in the MONTHLY WEATHER REVIEW, December, 1904, 32:554.

THE CHINESE WEATHER BUREAU.

By CO-CHING CHU, A. M.

[Dated: Harvard College, Cambridge, Mass., June 22, 1916.]

With the establishment of the Chinese Republic and the adoption of a constitution by the first Parliament in the years 1911 and 1912, a national weather bureau was officially instituted under the Board of Agriculture, with branch stations in various Provinces. Owing, however, to the lack of funds and men the organization has not progressed as we wished.

At present, there are two meteorological observatories in Peking. The one under the Board of Agriculture is located in the Central Agricultural Experimental Station. The other is called the "Central Meteorological Observatory" and belongs to the Board of Education. The latter observatory has already issued several bulletins, besides publishing a monthly magazine. The magazine had its start in the Fall of 1913, articles on astronomy, seismology, and earth magnetism have been published, as well as meteorological treatises. Each issue contains about 60,000 words (in Chinese).

In many other provinces besides Chili, of which Peking is the capital, Weather Bureau stations are maintained in connection with the Agricultural Experimental Stations, usually in the provincial capitals. The instruments used there are not of the first class, and in most cases have never been standardized. It is evident, then, that any work on forecasting is out of the question at the present stage of development of the governmental stations.

With the passing of Yuan's régime, we hope President Li and the new Parliament, which will be called together soon, will be more generous in their support of the weather bureau and other scientific enterprises.

NOTES.

Robert Frederick Stupart (*b.* Toronto, 1857), since 1894 director of the Meteorological Service of Canada, was among those honored by the King of England on the royal birthday celebration June 2, 1916. Sir Frederick is now a knight bachelor. (Nature, London, June —, 1916.)

Robert Henry Scott, M.A., D.Sc., Foreign Secretary of the Royal Meteorological Society, died at London, June 18, 1916 (*b.* Dublin, Jan. 28, 1833). Dr. Scott was Director of the Meteorological Office from 1867 to 1877 and Secretary of the Meteorological Council from 1877 to 1900.

He was the author of what is perhaps still the leading English textbook on Meteorology.

Dr. Scott's career is briefly outlined in this REVIEW, February, 1900, **28**:68.[1] An appreciative notice by W. N. Shaw also appears in Nature, London, June 29, 1916, **97**:365-6.

Prince Boris Borisovich Galitzin, Director of the Meteorological Service of Russia since 1913 (*b.* St. Petersburg, 1862), member of the Imperial Russian Academy of Sciences and Professor of Physics in the University of Petrograd, died May 4, 1916 (N.S., or Gregorian).[1]

[1] *Great Britain. Meteorological Office.* Meteorological office circular. No. 1 [London], June 20, 1916. 8°.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR MAY, 1916.

By H. C. FRANKENFIELD, Professor of Meteorology.

[Dated: U. S. Weather Bureau, Washington, June 7, 1916.]

GENERAL PRESSURE DISTRIBUTION OVER THE UNITED STATES AND CANADA, INCLUDING THE HAWAIIAN AND ALEUTIAN ISLANDS, ALASKA, AND THE WESTERN PORTIONS OF THE MIDDLE ATLANTIC OCEAN.

Pressure conditions over the Pacific Ocean and Alaska were quite well defined during the month with alternations of high and low pressure, each lasting about one week. An exception should be noted in pressure conditions in the vicinity of the Aleutian Islands where there was but a single depression of well-defined character, occurring from the 17th to 19th, inclusive. Otherwise pressure in this vicinity was high, as a rule, with occasional approaches to normal conditions. There were no great disturbances during the month. It should be noted, however, as a departure from the more usual conditions that the high and low areas over the North and the South Pacific were, as a rule, coincident throughout the month.

As would be expected from conditions over the Pacific Ocean, there was also an absence of severe disturbances over the United States. The most marked ones were those that moved over the extreme northern portions of the country, although there were several others of only slightly less intensity that developed in the Plateau Region and moved eastward and northeastward by way of the central Plains States and the Upper Lake Region. On the whole pressure was below normal during the month, only the second decade showing any positive departures of consequence and these only over the extreme north. Over the North Atlantic Ocean, as indicated by the barometric readings at Horta, Bermuda and Turks Island, there were alternate waves of moderately low and moderately high pressure, but nothing deserving of special mention.

STORM WARNINGS.

Small-craft warnings were ordered on the morning of May 4 on Lake Superior for fresh to strong southerly winds that were expected from the eastward movement of a low pressure area from the Canadian Northwest. Strong winds, really sufficient to justify a warning of a moderate storm, occurred over western Lake Superior and northern Lake Michigan, but they were of very short duration. On the evening of the 7th another disturbance from the Canadian Northwest had apparently reached eastern Minnesota and northwest warnings were ordered at 10 p. m. for western Lake Superior and northern Lake Michigan. Reports from Manitoba were missing and it afterwards developed that the storm center was really over the latter section, with lower pressure. Knowledge of this fact would have permitted the display over Lake Huron and southern Lake Michigan to have been made twelve hours earlier. On the morning of the 8th the disturbance was over northern Lake Superior with still further increased energy and the warnings were extended throughout the Lake Region, the direction being northwest on the Upper Lakes and southwest on the Lower Lakes. Westerly gales occurred generally, except on Lake Ontario, and at 8 p. m. of the 8th the storm center was over the lower St. Lawrence Valley. Northwest warnings were then ordered on the Atlantic coast from Delaware Breakwater to New York and on the following day moderate northwest gales occurred as forecast. By the evening of the 9th still another Canadian Northwest disturbance of more decided character than its two immediate predecessors had reached eastern South Dakota and storm warnings were ordered for the Upper Lakes, except southern Lake Huron, south and southwest gales being forecast for Lakes Superior and Michigan. On the following morning when the disturbance was central over eastern Manitoba the storm warnings were extended to southern Lake Huron and the Lower Lakes. Severe southwest and west gales occurred, lasting until the evening of the 11th, a number of stations reporting wind velocities of more than 50 miles an hour, with a maximum of 72 miles at Buffalo. Warnings had, of course, been continued and changed to northwest and the last (from Erie to Oswego) were not lowered until 9 p. m. of the 11th. On the evening of the 10th, when the storm was still over Lake Superior, southwest warnings were ordered on the Atlantic coast from Delaware Breakwater to Portland and on the following morning were extended to Eastport. Strong winds occurred as forecast.

On the morning of the 10th there were evidences of the approach of a disturbance toward Cuba. It did not appear to be of serious character and no mention was made of it until the evening of the 13th, when it was approaching the southern Florida coast. Advisory warnings were then issued to Atlantic and Gulf ports, and delay in shipping suggested until further advices. On the following morning (the 14th) with steadily falling, although not very low, pressure over Florida, with increasing easterly winds, northeast storm warnings were ordered from Jacksonville to Fortress Monroe. During the day moderate gales occurred on the northern Florida coast and fresh to strong winds on the Georgia and South Carolina coasts, but nothing of consequence farther northward. The disturbance continued to move slowly up the coast with steadily falling pressure and some rain but without strong winds, and on the morning of the 16th it was central over eastern South Carolina, with a barometer reading of 29.70 inches at Charleston. Special observations were called for and advisory warnings issued. Northeast warnings were ordered to be displayed at 6 p. m. at Block Island and Nantucket, and at 9:45 p. m. they were extended along the coast from Sandy Hook to Eastport. The storm had now increased considerably in energy, and on the morning of the 17th was central over southern New England with lowest barometer reading of 29.32 inches, and moderate gales had occurred from northern New Jersey to Cape Cod. These increased in severity, accompanied by rain, and by the evening of the 17th strong gales had occurred on the coast from New York to Maine, the storm center at that time being over the western Maine coast (29.28 inches). After this time there was some interference on the part of the western storm next to be mentioned, and a consequent rapid

diminution in energy, although pressure continued comparatively low until the night of the 19th.

During the 10th, when the preceding western disturbance was over Lake Superior at about its greatest intensity, a disturbance formed over the extreme Southwest with marked high pressure on the north Pacific coast. The Southwest disturbance did not move rapidly, but pressure fell slowly and steadily to the northeastward with the high area moving across the northern tier of States, and finally by the evening of the 13th the disturbance was central over northern New Mexico with promise of more rapid development and with a steep gradient toward the high area that at the time was over Lake Superior. Northeast storm warnings were accordingly ordered at 9:45 p. m. on Lake Superior from Duluth, Minn., to Ashland, Wis., and northeast and southeast warnings on the following morning at the remainder of the Upper Lake stations. The storm at this time was central over eastern Kansas, and during the next 24 hours easterly gales occurred on western Lake Superior, but only moderately strong winds over the remainder of the Upper Lakes. As the disturbance was moving slowly, the warnings were continued on the 15th for an additional 24 hours, except over the extreme southern portions of Lakes Michigan and Huron, and during the 16th the winds subsided.

On the morning of the 18th a moderate disturbance from the extreme Southwest was central near the mouth of the Rio Grande, and there had been some strong thunderstorm winds at Galveston. One p. m. special observations from Gulf stations did not indicate anything unusual, but the disturbance evidently moved rapidly across the northern Gulf and pressure fell rapidly during the afternoon. Accordingly northeast and southeast warnings of strong easterly winds were ordered at 5 p. m. from Bay St. Louis, Miss., to Cedar Keys, Fla. These occurred before evening, mostly in the form of thundersqualls, and by 8 p. m. only slight evidences of the disturbance remained. During the same time a disturbance had been developing over the middle Plateau. It did not move much until the evening of the 19th when it was central over western Colorado. By the following evening it was over southwestern Kansas with a fair high area over Lake Huron and, as a precaution, northeast warnings were ordered on Lake Michigan at 11 p. m. from Green Bay, Wis., to Michigan City, Ind. At 10:00 a. m. of the 21st, northeast and southeast warnings were ordered at the remaining Upper Lake stations, and at 4 p. m. southeast warnings at Lower Lake stations from Detroit to Erie. During the 21st the disturbance divided with a decided loss of energy, one section going to Iowa and thence northward to Minnesota, while the other section dissipated over northeastern Texas. Consequently the resulting winds on the Lakes, while strong, were by no means dangerous, and on the morning of the 22d the warnings were changed to "small craft."

On the morning of the 23d there was another Plateau disturbance over Nevada. It moved slowly eastward, and on the morning of the 25th it extended from eastern Colorado to eastern South Dakota with fair development. Northeast storm warnings were then ordered on Lake Superior from Duluth, Minn., to Ashland, Wis., and small craft warnings at remaining Lake Superior stations. During the day northeasterly gales occurred as forecast, diminishing during the night as pressure fell to the northwestward, and the disturbance lost its energy. The last warning of the month was a "small craft" on the 30th on the middle Atlantic and New England coasts, hoisted on account of a depression that had come out of the unsettled barometric conditions of the few previous days in the extreme West and had moved to the upper St. Lawrence Valley. Fresh to moderately strong winds occurred.

FROST WARNINGS.

While cool weather prevailed during much of the month, there were no general and decided frost periods owing to the more or less persistent cloudiness. During the first three weeks frosts were forecast about one-half the time for some portions of the Northern States, and while some of these warnings were verified, others were not, and the general results were not satisfactory owing to the excessive cloudiness. Frost warnings during the last 10 days of the month were less frequent and more successful. A heavy frost on the 31st in Upper Michigan was not forecast owing to the absence on the morning of the 30th of the pronounced conditions that developed during the day.

DISTRICT WARNINGS DURING MAY.

Chicago district.—Frost warnings were issued for some portions of the Chicago forecast district on 16 days during the month. On the 1st warnings were issued for Wisconsin, western Illinois, east and north-central Iowa, and southwestern Missouri, and warning of frosts or freezing temperature for Montana. These warnings were verified except in southwestern Missouri. An area of high pressure with freezing temperature was overspreading the Northwest on the morning of the 2d, following a disturbance centered over Colorado. Accordingly frost warnings were issued for the northern and western portions of the district. These warnings were verified generally except in Wisconsin where precipitation occurred during the night. On the 3d warnings were sent only to central Illinois, as the high pressure area was moving far to the southward, and a marked disturbance was developing over the far Northwest. This disturbance was centered over Manitoba on the morning of the 4th and was followed by cooler weather. Frost warnings were issued for North Dakota and northwestern Minnesota, but failed of verification on account of the immediate development of another disturbance over the Northwest.

No further warnings were required until the 7th when a disturbance of much force was moving eastward near the northern border, and was followed by a High of the North Pacific type. Warnings were issued for Montana, Wyoming, the western portions of the Dakotas, and northwestern Nebraska. Frost occurred on the morning of the 8th, as predicted, except in western North Dakota, where fresh winds prevented frost formation, and warnings were issued for frost the following night in Wisconsin, Minnesota, and northeast Iowa. The high pressure area advanced southeastward to the lower Ohio Valley and was followed by a marked disturbance from the north Pacific. As a result frost was not reported except in the cranberry bogs of Wisconsin. The northwestern storm had reached Manitoba by the morning of the 10th, and was followed by a High from the North Pacific States. Frost warnings were issued for the entire Northwest, and as far east as central Iowa and as far south as northern Kansas, and frosts occurred the following morning as far east as western Minnesota and as far south as Nebraska. On the 11th warnings of frost or freezing temperature were issued for Montana, Wyoming, and North Dakota, and frost warnings for western Nebraska,

South Dakota, Minnesota, and northern Wisconsin, including the cranberry bogs. These warnings were verified as a rule except from southern North Dakota southward to Nebraska, where cloudiness prevailed. As high pressure and freezing temperature still prevailed over much of the Northwest, warnings were again issued on the 12th for frost in northern Minnesota and the Dakotas and for frost or freezing temperature in Montana and Wyoming. However, rain set in over much of this area and prevented frost.

The next warnings were issued on the 14th for frost in western Kansas, and frost or freezing temperature in Montana, Wyoming, western Nebraska, and extreme western South Dakota. A disturbance was advancing northeastward over the Plains States, followed by high pressure and low temperature in the northern Rocky Mountain region. The warnings were verified as a rule. On the 15th warnings were issued for frost in Montana, Wyoming, western North Dakota, Kansas, and western and central Nebraska, and for frost or freezing temperature in western South Dakota. Frost occurred as indicated except in Kansas and eastern Montana, rain falling in the latter State. As high pressure still prevailed throughout the Northwest on the 16th, frost warnings were again issued for the northern States of this district, except Montana and western Wyoming and near Lake Michigan. The warnings were verified except in central Wisconsin and in Iowa. There was little change in conditions in the Northwest on the morning of the 17th and warnings were issued for Wisconsin, Minnesota, north-central Iowa, and the eastern portions of the Dakotas. There was no frost in portions of eastern Wisconsin, northern Minnesota, and eastern North Dakota on account of cloudiness. In Iowa frost covered the whole State, except the extreme south portion.

A small area of high pressure advanced from North Dakota to the Lake region during the 19th and 20th, causing frost in the cranberry bogs of Wisconsin. Warnings of this frost were issued on the 19th. On the 21st frost warnings were issued for Wyoming, but were not verified on account of the unexpected development of a disturbance over that region. On the 22d warnings were issued for Wyoming and Montana, and were verified except in portions of Montana where cloudiness continued. The last frost warnings of the month were issued for western Wyoming on the 26th and were fully verified.—*Chas. L. Mitchell, Assistant Forecaster.*

New Orleans district.—On May 1, with the crest of an area of high pressure over eastern Colorado and low temperatures over the Plains States, frost was forecast for Oklahoma, the northern and western portions of western Texas, the northwestern portion of eastern Texas, and the extreme northern portion of Arkansas. During the ensuing 24 hours the area of high pressure greatly weakened, and although minimum temperatures of 40° or slightly higher were recorded in Oklahoma and western Texas, no frost was reported.

A small-craft warning was ordered for the Texas coast at 1:15 p. m. on May 1, as special observations indicated that the depression at the mouth of the Rio Grande River was developing in strength. The wind velocities on that afternoon showed that the warning was justified.

Frost warnings were issued for Oklahoma and the Texas Panhandle on the morning of May 3 because of an area of moderately high pressure moving southeastward from the Rocky Mountain region. In the following 24 hours the high-pressure area moved to the Gulf coast and pressure was falling rapidly over interior sections, with a well-formed low to the northward. The temperature conditions show that the warning was justified, although frost was not reported.

Frost was forecast on May 11 for the northwestern portion of the Texas Panhandle because of low temperature northward, but a depression over the southern Plateau States extended its influence eastward and prevented frost formation.

On May 14 a decided trough of low pressure was central over Kansas, with a steep gradient and falling temperature in the rear. Frost was predicted as probable in Oklahoma, northwestern Texas, and northern central Texas. Minimum temperatures ranging from 40° to 50° occurred the following morning, but no frost was reported. This prediction was repeated on May 15 and was justified by the slight temperature fall ensuing, although frost was not reported.

From the conditions preceding and attending the wind velocities on May 18, when gales occurred at Galveston, Burrwood, and New Orleans, it would appear that these winds were due to the movement from west to east of a line of rapid pressure-falls not shown by the isobars of the weather maps. On the morning of the 18th a current velocity of 40 miles an hour from the north and a 12-hour maximum velocity of 60 miles north were recorded at Galveston. At the evening observation the 12-hour maximum velocity reported was 56 miles northeast at Galveston, while at New Orleans it was 35 miles southeast. At New Orleans, between 12:30 p. m. and 2:30 p. m. the pressure fell 0.25 inch, after which it rose gradually, the maximum velocity occurring at 1:56–2:01 p. m. Pressure developments somewhat similar occurred at Burrwood, La., where there was a maximum wind velocity of 48 miles northeast.

On May 21, because of a disturbance over Nebraska extending southward to Texas, small-craft warnings were ordered for the Texas coast at 9 a. m. and were fully verified. This disturbance was accompanied by a tornado in Oklahoma during the preceding night.

On May 24 at 8 p. m. a well-formed depression was central over the Rocky Mountain region, and the winds were fresh on the west coast of Texas. Southeast storm warnings were ordered for Texas but were lowered the next morning, as the disturbance moved northeastward and winds on the Gulf coast did not increase.—*Wm. B. Stockman, Assistant Forecaster.*

Denver district.—Frosts were common during May and severe frosts occurred much later than usual. Warnings were issued for some part of the district on the 1st to 3d, inclusive; 7th, 8th, 10th to 16th, inclusive; and 20th to 26th, inclusive. No severe frosts occurred without warnings.

On the morning of May 1 warning of frost was issued for Colorado and Utah and heavy frost in the northern and eastern portions of New Mexico. The warnings were fully verified except in the immediate vicinity of Salt Lake City. The warning of the 2d was for freezing temperature in the northeastern fourth of Colorado, while warnings for the Gunnison Valley were issued locally, based on the forecast for colder weather. The warnings were verified, the northern HIGH having overspread the district. The warnings of the 3d for northeastern New Mexico were verified, while the warnings for local frosts in Utah and western Colorado were verified only in part, owing to the intervention of cloudiness in Utah. The warning of the 7th for frost in high districts of Utah was fully verified, but in western Colorado the warning was not generally verified, the crest of the western high pressure having advanced more rapidly than expected, and north of the district. The warning of the 8th for local

frost in Colorado and Utah was not verified, owing to the cloudiness that attended the rapid southeastward movement of a low-pressure area from the northwest. The warning of the 10th for heavy frost with freezing temperatures in localities in northern and western Colorado and Utah and heavy frost in northern New Mexico and northern Arizona was verified in the greater part of Colorado and Utah, but in New Mexico and Arizona the warning was not verified, those sections having come under the domination of a low-pressure area that developed in the extreme southwest. The warning of the 11th for frost in extreme northern Colorado and in Utah; 12th for frost in Utah; 13th for frost in western Colorado and Utah; 15th for Colorado, Utah, and northwestern New Mexico were fully verified, weather conditions in the districts indicated having remained under the controlling influence of high pressure. The warning of the 14th, the most important of the month, for heavy frost in Colorado, Utah, northern New Mexico, with freezing temperature in northeastern and southwestern Colorado, southern Utah, and northwestern New Mexico was fully verified, the HIGH in this case moving southeastward. The warning of the 16th for Colorado and New Mexico was not generally verified, owing to the cloudiness which attended the development of a LOW in the southwest. The warnings of the 20th and 21st, which were issued in anticipation of a rapid filling in of a low pressure area over Colorado, were premature and not verified. The warning of the 22d for Utah was verified, notwithstanding the fact that a LOW was in course of development in Nevada on the morning of the 23d. The further development of this LOW prevented frosts on the morning of the 24th, warnings having been issued for local frosts in western Colorado and Utah. The warnings of the 24th were for frost in northern Arizona and Utah and were fully verified, these localities coming under the influence of the front of the western HIGH. On the 25th warnings were issued for local frost in western Colorado, northern Arizona, and Utah. These were verified except in northwestern Utah. The warning of the 26th was for western Colorado and northern New Mexico, and was verified except in parts of northeastern New Mexico.—*F. H. Brandenburg, District Forecaster.*

San Francisco district.—A forecast for showers in the north portion of northern California was issued on the morning of the 6th, and the showers occurred in that section in the afternoon and night. On the morning of the 8th warnings of showers in the extreme north portion on the 9th were issued, and showers occurred in the afternoon and night of the 8th and on the 9th. Showers occurred in the north portion of northern California on the 18th without warnings, and an indefinite forecast for showers in northern California and Nevada issued on the 18th was partly verified the following night and day. Showers in Nevada on the 24th were without warnings.

A severe frost occurred in the coast valleys and delta section, with the clearing weather on the morning of the 7th, without warnings, and did considerable damage to vines. A warning of frost in exposed places in northern California was issued on the 9th, and the following morning frosts, doing considerable damage, occurred in portions of the San Joaquin valley and on the north coast.

Storm warnings were ordered 14 times during the month and were verified in nearly every instance. No verifying velocities occurred without warnings, and there was no damage to shipping.—*G. H. Willson, District Forecaster.*

Portland, Oreg., district.—No unusual characteristics were noted in connection with the weather during the first part of May, except the somewhat sudden appearance on the British Columbia coast of a marked disturbance on the evening of the 7th; its eastward movement permitted a return to normal weather conditions by the 9th. On the 10th the Pacific "High" [1] shifted northward to the coast of British Columbia, resulting in a period of fair weather with temperatures below normal and general frosts. Although this "High" hovered over the North Pacific coast during the remainder of the month, its shifting to the northern California coast and back again resulted in generally unsettled weather from the 17th on, with a considerable amount of cloudiness, abnormally low temperatures, and some local showers. The development of a marked disturbance over the Basin States on the 23d, and its subsequent leisurely eastward advance, aided very materially in bringing about the unusual weather conditions of the latter part of the month. The average daily departure from normal temperature was $-2.1°$.

A storm warning was issued for the Oregon coast and the mouth of the Columbia River on the evening of the 7th. The warning should have been extended to include Seattle also, where moderate to fresh gales occurred, though they were presumably in the nature of squalls and of short duration. Small-craft warnings were issued on four occasions for exposed localities in the district, and it is believed that all were verified; the one issued on the 8th should have been a storm warning for Puget Sound, as the verifying velocity was exceeded at Seattle. On the 7th the wind attained a velocity of 72 miles an hour from the southeast at North Head, Wash., but no known casualties resulted.

Four frost warnings were issued for the entire district, of which two were verified, one was partially verified, and one was a failure due to the development of cloudiness. Twelve frost warnings were issued covering part of the district, and of these, six were fully verified, three partially verified, and three were failures due to the sky becoming clouded, though in one of these instances snow resulted with a temperature of 32°. In the Rogue River Valley, where orchard heating is resorted to in order to prevent damage to fruit from low temperatures, and where we had a representative from this office in the field, our forecasts were very satisfactory; our morning weather forecasts included the information that light or heavy frosts were expected, and in the evening another telegram giving the expected minimum temperature for the "key" station at Medford was sent. The comparison of the predicted and the resulting temperatures for the dates on which frost warnings for the Rogue River Valley were issued are given here:

Dates of P. M. warnings.	Predicted temperature.	Reported minimum temperature.
	°F.	°F.
May 6	29	29
9	[2] 27	33
10	29	28
11	29	29
12	31	31
13	32	33

[1] The term "High" used above refers to that portion of the normal Pacific high pressure area as drawn on Weather Bureau Chart "A."

[2] If sky clears. On this date one of the substations located at Modoc Orchard reported a minimum temperature of 27°. The qualification "if sky clears" was necessary, as it was uncertain whether or not the cloudiness would continue throughout the night.

LIVE-STOCK WARNINGS.

Six sets of warnings were issued for expected weather conditions detrimental or dangerous to the live-stock industry, on the 6th, 10th, 17th, 20th, 22d, and 25th. These were really consecutive warnings, rather than sets, as they covered practically the entire period from the 6th to the close of the month, when there appeared no further necessity for continuing them. The following warnings were issued:

May 6, 1916.—Unsettled with local showers and cooler weather Sunday and Monday, probably clearing Tuesday and Wednesday with cold nights. Warmer last of week.

May 10, 1916.—Fair weather with cold nights and higher day temperatures indicated for remainder of week.

May 17, 1916.—Unsettled, showery, cooler weather indicated for next two or three days.

May 20, 1916.—Fair weather indicated next two or three days. Warmer days, cooler nights Monday, Tuesday.

May 22, 1916.—Unsettled with local showers indicated for next day or two. Temperatures will probably continue moderately low.

May 25, 1916.—Unsettled, partly cloudy weather to-day and Friday, probably fair, following two or three days with slowly rising temperatures.

A change in weather conditions resulting in light precipitation in live-stock districts really called for another warning on the morning of the 21st, but low temperatures and precipitation were not extreme and no reported hardship or damage occurred, and our warning of the 22d (p. m.) covered subsequent meteorological conditions. The stockmen desire advance information, when practicable, of important weather changes for better or worse, as many of them govern themselves accordingly during lambing and shearing time. The warnings have been reasonably accurate and timely, and newspaper and personal expressions of satisfaction and commendation received have been very gratifying indeed, as they indicate the practicability of this feature of Weather Bureau forecast work.—*T. Francis Drake, Local Forecaster.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, MAY, 1916.

By ALFRED J. HENRY, Professor in Charge.

[Dated: River and Flood Division, Weather Bureau, June 28, 1916.]

FLOODS IN THE UPPER MISSISSIPPI, SPRING OF 1916.

Some account of the floods in the upper reaches of the Mississippi was given in the April, 1916, REVIEW, page 214. Owing largely to circumstances there described, flood conditions continued during May, 1916, being unusually severe between Davenport and the mouth of the Iowa River. Early in April the levees protecting the Illinois side of the river opposite Davenport, Iowa, gave way, and on May 4 the levees protecting Muscatine Island, on the Iowa side of the river, also gave way. By reason of these breaks and the fact that the river continued at a relatively high stage for nearly a month, the inundation proved disastrous to the occupants of the lowlands on both sides of the river.

Approximately 60,000 acres of agricultural land was inundated in the Davenport district, in places to a depth of 12 feet. In a subsequent part of this report the approximate value of the loss occasioned by these floods will be given.

The water which caused the floods in question came principally from the headwaters of the main stream, but a very considerable part was contributed by the Wisconsin River. In the stretch between Keokuk, Iowa, and Louisiana, Mo., the flood conditions were at times intensified by local rains in northeastern Missouri and adjacent portions of Illinois, specially on the 13th and 14th, thus prolonging the period of high water much beyond the usual duration of spring floods.

Notwithstanding the long-continued period of high water between Keokuk, Iowa, and Louisiana, Mo., the Mississippi at St. Louis, Mo., about 100 miles below Louisiana, did not reach the flood stage until the end of the month, as may be seen by the statistics of Table 1.

Approximate loss due to floods in the Upper Mississippi, April–June, 1916.

Tangible property, levees, highways, bridges, factories, etc.	$164,241
Tangible property of railroads	133,000
Farm property, crops (matured)	110,200
Farm property, crops (prospective acreage, 120,110)	973,950
Live stock and other movable farm property, including buildings	57,100
Suspension of business	80,150
Total	1,518,641
Estimated saving by warnings	1,395,700

FLOOD IN THE LOWER MISSISSIPPI (VICKSBURG DISTRICT), SPRING OF 1916.

By W. E. BARRON, Section Director.

[Dated: Weather Bureau office, Vicksburg, Miss., June 10, 1916.]

First rise.—The relatively high stages that prevailed in the Mississippi River during the summer of 1915 were the subject of much comment; and the lowest stages reached in the autumn were 14.8 feet at Arkansas City, November 15; 10 feet at Greenville, November 15 and 16; and 11.5 feet at Vicksburg, November 17. A rise then set in which culminated early in December, followed by a fall to 21 feet at Arkansas City, on December 17 and 18; 15.7 feet at Greenville, on December 18 and 19; and 18.2 feet at Vicksburg, on December 20 and 21. The rise that immediately followed came out of the Ohio, Cumberland, and Tennessee Rivers. On January 1, 1916, the following stages obtained in the Vicksburg district: Arkansas City, Ark., 40 feet; Greenville, Miss., 32.4 feet; Vicksburg, Miss., 35.6 feet. These are unusually high stages for the opening of the year. The rise continued without interruption until the crest stages were reached, in February, being augmented by two additional rises from the Ohio, one each from the Cumberland and Tennessee, one from the Mississippi above Cairo, and a succession of rises in the Arkansas and White Rivers, which delivered a great quantity of water to the Mississippi in advance of the arrival of the crest of the main stream. The stages that resulted were the highest known, viz., 56.4 feet at Arkansas City, February 10 and 11; 50.7 feet at Greenville, February 11 to 14; 48.8 feet at Lake Providence, La., February 15; and 53.9 feet at Vicksburg, February 15. These stages exceeded those of 1912 by 1 foot at Arkansas City, 0.1 foot at Greenville, 0.6 foot at Lake Providence, and 1.8 feet at Vicksburg, and those of 1913 by 1.3 feet at Arkansas City, 0.3 foot at Greenville, 0.8 foot at Lake Providence, and 1.6 feet at Vicksburg. The highest stage previously recorded at Vicksburg, that of 1897, was overtopped by 1.4 feet. The river was above flood stage at Arkansas City (42 feet) from January 4 to March 15, 72 days; at Greenville (42 feet) from January 18 to March 5, 48 days; and at Vicksburg (45 feet), from January 17 to March 16, 60 days.

The Tallahatchie River at Swan Lake, Miss., reached flood stage (25 feet) during January 9, and continued above flood stage until March 13. The crest was 29.1 feet, February 11 to 14. This rise was due to rains that fell over the Tallahatchie Watershed simultaneously with those over the Mississippi River and tributaries. In the Yazoo River, the highest stage at Greenwood, Miss., which is situated four miles below the confluence of the Tallahatchie and Yalobusha Rivers, was 31.4 feet, or 4.6 feet under the flood stage, February 13 to 17. At Yazoo City, where the run-off from the river is retarded by the backwater effect of the Mississippi, the river reached flood stage (25 feet) on January 28, and continued above flood stage till March 20, a period of 53 days. The highest stage was 29.9 feet, on February 18.

The first flood warning was issued for Arkansas City on December 28, 1915. Warnings of stages of 47 feet at Arkansas City, 40 feet or more at Greenville, and about 45 feet (flood stage) at Vicksburg were issued on January 3, 1916. On January 5, it was possible to forecast stages of 48 to 49 feet at Arkansas City, 42 feet (flood stage) or more at Greenville, and close to 47 feet at Vicksburg. On January 11, forecast was made that the water then in the rivers would give the following stages: Arkansas City, 49 to 50 feet; Greenville, 43 to 44 feet; Vicksburg, 47 to 48 feet. Had these stages been the limit there would have been no marked flood. At the time, practically all of the upper Mississippi and the tributaries were falling, but general rains and snows were in progress, and on the following day (January 12), with a fresh rise in progress throughout the length of the Ohio, the public was advised that these rains would give higher stages than those previously forecast, and delay the crest into February; also, that flood stage would be passed at Vicksburg three days later.

On January 15, the Ohio River having reached its crest at Cincinnati, a warning was issued that the Mississippi would pass 49 feet at Arkansas City, and flood stage at Greenville and Vicksburg by Monday, the 17th, and continue rising until February 3 to 7, reaching 52 feet or more at Arkansas City, 46 to 47 feet at Greenville, and 50 to 51 feet at Vicksburg. On January 19, this was modified by the statement that without further rains it was probable that the lower figures named would not be exceeded. However, heavy rains fell over Arkansas on January 21 and 22, and this estimate was increased approximately one foot at each place.

Another wet period that set in on January 27 over the Arkansas and White Rivers and later spread to the upper rivers further altered the situation, and the forecast was changed from day to day until Monday, January 31, when the public was advised that the continued heavy rains over the watersheds would prolong the rise and give increased stages, passing 55 feet at Arkansas City, 50 feet as Greenville, and 52 feet at Vicksburg. The next day, it was explained that these stages would be reached February 8 to 10, and that a definite forecast of the crest stage was not yet practicable.

On February 3, the following warning was issued:

"Barring breaks in the main line levees, the Mississippi will pass 56 feet at Arkansas City, 50.5 feet at Greenville, and 52.5 feet at Vicksburg by February 8 to 10, and continue rising."

In other words, the public was warned that the flood in progress would overtop all previous high water stages at points in the district. Beyond these stages, the situation was complicated by the discharge of water around the upper end of the Mississippi River levees into the upper Tensas Basin, augmented by breaks in the Arkansas River levees on February 1 and subsequent dates, as well as by the unknown effect of the backwater overflow into the lower Yazoo basin. Hence, on February 5, the information was given out that with the large amount of water then passing out above the end of the Mississippi River levees in Arkansas, the crest at Arkansas City would not be over 56 to 56.5 feet, about February 17, and that if the levees held, Greenville would crest at 50.5 to 51 feet, about February 18, and Vicksburg at 53 to 53.5 feet, about February 20. This forecast was changed on February 8 to 56 feet or slightly over at Arkansas City by February 17, 51 feet or slightly over at Greenville by February 18, and close to 54 feet at Vicksburg by February 19 or 20. The forecast of February 5 proved to be the better for Arkansas City and Greenville, and that of February 8 the better for Vicksburg, though the dates were placed a little too far ahead. As the stages from Arkansas City to Vicksburg were then abnormally high as compared with the stages at Memphis and Helena, the rise that was continuing at those points did not have its normal effect, and the crests at Arkansas City and Greenville were almost coincident with the crest at Helena, when ordinarily they would have occurred several days later.

The rise had almost spent itself at Vicksburg when a crevasse occurred on February 15, in the Buck Ridge levee, 25 miles below Vicksburg, in the New Orleans district. The discharge resulting increased the slope of the water between this crevasse and Vicksburg, and produced a fall of one-tenth of a foot by the following morning. But after this readjustment, the large quantity of water in the lower Yazoo basin held the river at Vicksburg stationary for two days before a steady fall commenced.

Second rise.—By the 1st of April the Mississippi had receded to 34.6 feet at Arkansas City, when another rise began, the result of simultaneous rises in the Ohio, upper Mississippi, Arkansas, and White Rivers. The following stages were reached: Arkansas City, 47 feet, April 20–22; Greenville, 40 feet, April 21–22; Vicksburg, 45.2 feet, April 23–26. The river was above flood stage at Arkansas City (42 feet) from April 9 to May 5, inclusive, and at Vicksburg (45 feet) from April 22 to 28. Ample and accurate warnings for this rise were issued well in advance.

Crevasses and overflow.—On the right bank south of the Arkansas River, the whole of this district is protected by the Arkansas and Mississippi River levees, with the exception of a gap of 2.9 miles between them, through which Cypress Creek flows into the Mississippi River. South of Cypress Creek there is a ridge of comparatively high ground about 12 miles long, known as Amos Bayou Ridge. Under present conditions water begins to flow over this ridge into the upper Tensas Basin at a stage between 51 and 52 feet on the Arkansas City gauge. There were no crevasses in the Mississippi River levees, but several occurred along the Arkansas. Two or three occurred on February 1 in the stretch between Commings and South Bend, Lincoln County; another on the 3d somewhat farther down at Pendleton, Desha County. Finally, one occurred at Rosemary, on Lake Jefferson, about 5 miles above the open end of the Arkansas River levee. As the territory behind this levee was already overflowed, this crevasse had little effect.

Along the Arkansas, above the end of the levees maintained by the Mississippi River Commission, the overflow from the crevasses amounted to 194 square miles. The water from these crevasses, mingled with the backwater from the Cypress Creek gap, was discharged over Amos Bayou Ridge and spread southward between the Mississippi River and the Little Rock and Alexandria line of the St. Louis, Iron Mountain & Southern Railway, following the courses of the Bœuf River and Bayou Lafourche into the Ouchita, and of Bayou Macon into the Tensas, thence into the Black and lower Red Rivers. The most important towns affected were Arkansas City, Desha County, and Lake Village, Chicot County, Ark. At Arkansas City the water from this overflow reached a height equivalent to a stage of 48.8 feet on the river gauge at that point, or 1.8 feet higher than was reached in 1913. The water was 6 to 8 feet deep in the streets. The area thus overflowed from backwater was 2,247 square miles as compared to 1,591 square miles in 1913, making a total overflow of 2,341 square miles[1] on the right bank from the Arkansas River to the lower limits of this district.

On the left bank of the Mississippi the levees are continuous from the bluffs below Memphis, Tenn., to Eagle Bend, Warren County, Miss., leaving an opening of about 19 miles at the lower end of the Yazoo Basin. During every flood the Mississippi overflows into the lower portion of this basin, and even for a considerable distance above the lower end of the levees. The area of the 1916 overflow in Mississippi was 1,218 square miles,[1] comprising parts of Issaquena, Sharkey, Yazoo, and Warren Counties.

While the excess of the flood heights of 1916 over those of previous years may be attributed to the large quantity of water added by the Arkansas and White Rivers with the levees holding from Cairo to below Vicksburg, it can not be said that the ultimate stages have been reached in this district, owing to the fact that the gaps at Cypress Creek and at the lower end of the Yazoo Basin have effects similar to those of open crevasses. Should the Cypress Creek gap be closed, or should the levees in Mississippi be extended, gauge heights from Arkansas City to Vicksburg would be more or less increased.

[1] As reported by United States Engineer officers.

Although there were no crevasses in the Mississippi River levees in this district, and the communities subjected to overflow had ample warning and opportunity to protect much of their property, the losses nevertheless were great, and much inconvenience resulted. Thousands of acres of overflowed territory were fertile farm lands. At Arkansas City, Ark., the water was 6 to 8 feet deep in the streets, and the water and light plants were out of commission.

Opposite the breaks along the Arkasnas River the St. Louis, Iron Mountain & Southern Railway was out of commission between Grady and Dumas, a distance of 19 miles, from February 1 to February 10. Farther south in the backwater district, the Arkansas City branch of the same railroad was not in operation between Tripp Junction and Arkansas City (7 miles), from February 1 to February 28, and from Dermott to Halley (6 miles) from February 4 to February 27; the Hamburg branch from Montrose to Luna Landing (19 miles) from February 1 to March 27; while the line running south from McGehee, Ark., to Lake Providence, La., known formerly as the Morgan, Helena & Louisiana, was out from McGehee to Lake Village, Ark., from February 4 to March 4, and at times as far south as the Louisiana line, a distance of 50 miles.

As the water front at Vicksburg, Miss., is unprotected by permanent levees, and the stage was higher than ever before, the damage locally was correspondingly greater. The stage in the Yazoo Canal at the Government fleet, 3 miles above the Weather Bureau gage, was 1.1 feet higher than that at the latter, which is below the city on the river. Levee Street and the entire local yards of the Yazoo & Mississippi Valley Railroad would have been 1 to 3 feet under water had not the railroad company built temporary levees and lowered the seepage by pumping. Four steam pumps were in operation. This curtailed local property losses and enabled many of the warehouses along the harbor front to continue business. But the railroad company found it necessary to shut down most work at its shops from February 11 to March 6, throwing an average of 325 men out of employment. Other industrial plants used most of their employees in measures for protecting and saving their plants and stocks. At the city waterworks, below town, the water was up to the floor in the pump house.

In the backwater district of Mississippi, railroad train service was continued as long as possible. The Silver City branch of the Yazoo & Mississippi Valley Railroad, a line having a low grade, was closed to traffic between Kelso and George, Miss., on February 3, and the service was not resumed again until March 28. Nearly all of this 27-mile stretch of track was submerged. On the main line of the Yazoo & Mississippi Valley Railroad train service south in and out of Vicksburg was discontinued from February 10 to 26, on account of the depth of water over the tracks in several places. North from Vicksburg to Rolling Fork, Miss., traffic on the main line was discontinued from February 10 to March 1, the track being all under water from Redwood to Rolling Fork, a distance of 32 miles. In the deepest place the water stood 57 inches over the rails. It was over this line that on February 17 Mr. A. H. Egan, superintendent of the railroad, at considerable hazard, brought a special train bearing the Flood Control Committee of the National House of Representatives, the trip being arranged for the purpose of enabling the committee to view the conditions obtaining in the overflowed district. A statement of losses due to the flood follows.

Approximate money loss in Vicksburg district due to the flood of January–March, 1916.

General loss (tangible property)	$410,000
Loss of crops (matured)	70,000
Loss of crops (prospective)	260,000
Loss of live stock	22,000
Suspension of business	200,000
Total	962,000

In the above table the losses from all sources in this district, outside those of railroads and telegraph lines, are given as $962,000, and the value of property saved by the warnings of the Bureau is estimated at $1,650,000. These estimates were made after weighing all reports received. The loss to prospective crops was in small part a loss to oats and other crops already in field at the time of the flood, but in larger measure it was due to the ravages of cutworms, which appeared in the fields that had been planted after the overflow subsided, devastating a vast acreage of cotton and corn and rendering replanting necessary.

The cost of high-water protection aggregated $220,000 for the expenditures of the Government and the State boards in the high-water fight, and probably $50,000 for private measures, such as building private levees, moving tenants, live stock, and farm products from plantations, and removal of goods to places of safety.

Much credit is due to Maj. J. R. Slattery, in charge of the third district office of the Mississippi River Commission, for his able direction of the long-continued fight to hold the levees in this district. While the efforts of the workers were helped by generally favorable weather conditions during the critical period, it is conceded that the successful outcome was due to persistence and the policy of handling the labor situation without the free distribution of rations. The fight was continued until about March 1, when all danger was past.

FLOODS IN OTHER RIVERS.

The rainfall distribution during May both in time and space caused a moderate number of relatively unimportant floods, as may be seen from the statistics given in Tables 2 to 5. From Table 5 it may be noted that neither the Colorado nor the Columbia was in severe flood as a consequence of the heavy snow cover which overlaid mountain tributaries of those rivers.

Floods in western New York.—As LOW No. 7, Chart III (XLIV–57), passed slowly northeastward from Iowa, where it was central on the 14th, rain fell almost continuously over western New York and adjacent regions for a period of about four days. The rains on the 14th and 15th were of moderate intensity, but on the afternoon of the 16th a series of thundershowers, some of which were unusually heavy, occurred over the counties of Wyoming, Allegany, Cattaraugus, and Livingston. Doubtless the rains of the two previous days had completely saturated the soil, and accordingly a large portion of the storm waters quickly found their way into the streams. Press reports indicate that watercourses—mere creeks ordinarily—rapidly became swollen rivers, overflowing villages, washing away bridges, damaging railroad tracks and other property. The loss sustained, according to press reports, was close to half a million dollars.

The only river-gaging station in the flooded region was that of Olean, N. Y., on the Allegheny River, where that river rose 11.6 feet in the 24 hours ending on the morning of the 17th. The Genesee River Valley was in the direct course of the storms, and while some apprehension was felt in the city of Rochester, nevertheless the flood wave passed into Lake Ontario without doing serious damage in the lower reaches of the stream.

Daily precipitation, in inches and hundredths, in western New York, May 14–18, 1916.

Stations.	Elevation.	May, 1916.					Total.
		14	15	16	17	18	
Western plateau:	*Feet.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Alfred	1,720	0.17	0.39	2.67	0.75	0.05	4.03
Allegany	1,440	0.06	0.17	0.37	2.36	1.03	3.99
Angelica	1,440	0.00	0.91	2.40	0.79	0.01	4.11
Avon	585	0.06	0.45	2.20	0.86	0.07	3.64
Bolivar	1,800	0.20	0.08	1.85	0.60	0.15	2.88
Haskinville	1,920	(*)	0.34	1.85	1.44	T.	3.63
Hunt	1,150	0.04	1.40	2.53	0.00	0.03	4.00
Lauterbrunnen	1,260	0.11	0.20	3.04	0.72	0.05	4.12
Olean	1,402	0.00	0.20	0.55	2.76	0.14	3.65
York	760	0.11	0.36	4.51	0.54	0.11	5.63
Great Lakes region:							
Brockport	537	0.09	0.64	2.32	0.82	T.	3.87
Elba	750	0.12	0.85	1.83	0.62	0.06	3.48
Hemlock	920	(*)	0.32	4.30	0.10	0.02	5.74
Perrysburg	1,500	0.27	0.25	0.70	0.10	0.10	1.42
Rochester	523	0.08	0.66	2.95	0.02	T.	3.71
Shortsville	660	0.06	0.28	1.60	0.78	T.	2.72

* Included in next measurement.

The daily amounts of rainfall at cooperative stations in western New York have been supplied by Prof. W. M. Wilson, of Ithaca, N. Y., and appear in the small table above. Similar data for about 100 stations in New York appear in "Climatological Data, New York Section, May, 1916." The rainfall data show, as has often been shown before, the increasing flood menace which attends moderately heavy rains on saturated ground. Unfortunately no accurate record of the response of the rivers to the storm waters is available, except for the single station before mentioned, but practically all newspaper accounts agree in the statement that the streams rose with remarkable rapidity.

Hydrographs for typical points on several principal rivers are shown on Chart I (XLIV—55). The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

TABLE 1.—*Floods in the Mississippi River and tributaries during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Mississippi	St. Paul, Minn	14.0	1	1	14.1	1
Do	La Crosse, Wis	12.0	1	5	13.2	1
Do	Dubuque, Iowa	18.0	1	7	19.8	3
Do	Prairie du Chien, Wis	18.0	1	2	18.3	1
Do	Clinton, Iowa	16.0	1	10	18.0	5
Do	Davenport, Iowa	15.0	3	9	15.9	6
Do	Le Claire, Iowa	10.0	1	12	12.1	5
Do	Muscatine, Iowa	16.0	1	11	17.7	7,8
Do	Keokuk, Iowa	14.0	1	19	16.4	15
Do	do	14.0	25	25	14.1	25
Do	Warsaw, Ill	17.0	1	18	19.4	15
Do	Hannibal, Mo	13.0	1	31	19.1	16
Do	Louisiana, Mo	12.0	1	31	17.5	16
Do	Quincy, Ill	14.0	1	30	18.6	15,16
Do	Grafton, Ill	18.0	5	24	20.7	19,20
Do	do	18.0	28	(1)	20.8	31
Do	St. Louis, Mo	30.0	31	(1)	30.0	31
Do	Arkansas City, Ark	42.0	1	5	44.4	1
Do	Vicksburg, Miss	45.0			44.5	1
Do	Baton Rouge, La	35.0			34.5	4
St. Croix	Stillwater, Minn	11.3	1	12	14.0	1
Do	do	11.3	23	(1)	13.9	31
Illinois	La Salle, Ill	18.0	16	25	19.7	18,19
Do	Beardstown, Ill	12.0	1	5	12.4	1
Do	do	12.0	15	31	14.4	31
Missouri	Hermann, Mo	21.0			20.7	30
Milk	Havre, Mont	9.0	30	31	9.3	31
Blue	Blue Rapids, Kans	21.0	14	14	21.5	14
Grand	Chillicothe, Mo	18.0	14	21	27.0	17
Do	do	18.0	25	30	25.1	29
Allegheny	Olean, N. Y	12.0	17	17	13.9	17
Scioto	Circleville, Ohio	7.0	7	9	9.9	8
Miami	Tadmor, Ohio	12.0	8	8	13.2	8
Wabash	La Fayette, Ind	11.0	16	18	13.9	16
French Broad	Asheville, N. C	4.0	24	24	4.3	24
Cottonwood	Emporia, Kans	19.5	31	(1)	21.4	31
Neosho	Le Roy, Kans	24.0			23.0	30

[1] At or above flood stage at close of month.

TABLE 2.—*Floods in the rivers of Texas during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Neches	Rockland, Tex	20.0	4	10	25.2	6
Do	do	20.0	24	26	21.3	25
Trinity	Fort Worth, Tex	20.0			19.8	2
Do	Dallas, Tex	25.0	2	8	34.8	4
Do	Trinidad, Tex	28.0	5	15	35.9	12
Do	Bridgeport, Tex	20.0	1	1	20.0	1
Do	Liberty, Tex	25.0	Apr. 24	15	27.4	9,10
Do	do	25.0	23	31	27.2	29,30
Colorado	Columbus, Tex	24.0	23	23	24.0	23
Guadalupe	Gonzales, Tex	22.0	25	25	22.3	25
Do	Victoria, Tex	16.0	26	28	18.2	27
Rio Grande	San Marcial, N. Mex	11.0	Apr.—	(?)	15.3	14

TABLE 3.—*Floods of the South Atlantic and East Gulf States during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Dan	Danville, Va	8.0	24	24	8.0	24
Roanoke	Weldon, N. C	30.0	26	26	30.8	26
Santee	Rimini, S. C	12.0	27	28	12.6	28
Do	Ferguson, S. C	12.0	6	....	11.9	29
Saluda	Pelzer, S. C	7.0	25	25	7.8	25
Wateree	Camden, S. C	24.0	25	25	24.0	25
West Pearl	Pearl River, La	13.0	11	12	13.3	11,12
Do	do	13.0	26	31	15.2	27

TABLE 4.—*Floods in the rivers of Michigan and New England during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Cass	Vassar, Mich	14.0	28	29	14.9	29
Tittabawassee	Midland, Mich	12.0	11	12	12.6	11
Grand	East Lansing, Mich	7.5	16	18	9.3	17
Do	Grand Ledge, Mich	6.5	....	....	6.4	17
Connecticut	White River Junction, Vt	13.0	18	19	13.1	18
Merrimac	Franklin Junction, N. H	13.0	18	18	14.9	18

TABLE 5.—*Floods in the rivers of the Pacific slope during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Colorado	Topock, Ariz	14.0	14	21	17.8	17
Gunnison	Sapinero, Colo	16.0	8	14	17.8	10,11
Do	Paonia, Colo	8.0	6	13	9.1	10
Do	Delta, Colo	9.0	10	11	9.2	10
Columbia	Vancouver, Wash	15.0	7	18	18.3	11
Do	do	15.0	22	26	15.5	24
Clearwater	Kamiah, Idaho	12.0	7	7	12.2	7
Willamette	Portland, Oreg	15.0	7	18	18.1	11
Do	do	15.0	23	25	15.2	24,25
Kings	Piedra, Cal	12.0	4	10	12.7	6
San Joaquin	Firebaugh, Cal	12.0	....	....	11.9	13
Do	Lathrop, Cal	17.0	....	....	16.9	9

RAINFALL AND FLOODS IN CHINA.

At the request of the Chinese Government the American Red Cross Society appointed in 1914 a board of engineers, including Col. William L. Sibert, Prof. Daniel W. Meade and Mr. A. P. Davis, to report on a method of preventing or mitigating the great damages caused by the floods of the Hwai-ho (which lies between the Hwang and the Yangtze rivers). Among the party which visited the drainage basin and studied the physical conditions was Mr. S. T. Suen who made a report on the rainfall conditions over the basin and has published an abstract of his paper in the Chinese Students' Monthly for March, 1915.[1]

After discussing the causes of rainfall and of floods Mr. Suen takes up the climate and rainfall of China, particularly the latter and bases his study upon the same compilation of data by Louis Froc which Mr. Chu has employed for his study on another page of this issue.

Mr. Suen finds that the intense summer heat of the subtropical southern portion of China maintains the atmosphere there in a state of unstable equilibrium, so that there the convective rainfall accompanying the frequent thunderstorms is heavy.

Again the prevailing summer wind is an east wind heavily loaded with moisture from the Pacific. This moisture is combed out by the mountain ranges close to and paralleling the coast, so that there is a heavy "orographic rainfall" on the windward slopes of the mountains and a correspondingly drier climate farther inland. The westward-pointing rain shadow of these ranges is marked even in the interior.

In addition to the two causes mentioned, and the most fruitful, is the heavy cyclonic rainfall which accompanies the typhoons that frequently visit the southeastern part of China during the summer and fall months.

In general the summer rainfall is much heavier than the winter fall; this is shown also by the maps on pages 280-1. This is particularly the case for the extreme southern and northern regions; the middle, the Yangtze valley, and the coast districts have a more uniformly distributed fall. But a given percentage of the annual fall means three times as much rain in the southern region as it does in the extreme north. The winter precipitation in northern China is very small and usually in the form of snow so that the summer rainfall there, while not as heavy as in the south, makes a preponderating percentage of the total.

Rainfall and flood.—Some Chinese stations have observed 20 to 25 inches of rain resulting from a single storm. Such excessive rain invariably leads to floods. A storm of 5 to 10 inches may be sufficient to produce a flood if the character of the drainage area is favorable thereto; and in the valley of the Hwai-ho floods are frequently brought about even during years of normal rainfall, by reason of the imperfect drainage system. An examination of the map of China will recall to the reader that the lower course of the Hwai-ho labors through the maze of a temporarily abandoned portion of the delta of the Hwang-ho. For example, the flood of July, 1906, in this valley was accompanied by an average fall of 7 inches of rain; in the flood of August, 1910 over the same area, resulting in the famine of 1911, more than 11 inches of rain fell over the drainage area of the Hwai. In Anhwei and 10 miles north of Pengpu there was a fall of 25 inches in 48 hours during this storm of August, 1910. In the Ohio flood of 1913, the record for half a century of observations, an average of 8 inches of rain in three days fell over the Ohio basin.

A great flood occurred in the Sikiang valley during the summer of [1914], but so far no rainfall reports have been received.

TABLE 1.—*Mean monthly number of storms accompanied by more than 1 inch of rain.*

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Tamingfu	0.0	0.0	0.4	0.0	0.2	0.4	1.0	0.8	1.4	0.4	0.0	0.0
Weihweifu	0.0	0.0	0.0	0.0	0.0	0.4	1.4	0.6	1.4	0.0	0.0	0.0
Hoklu	0.1	0.0	0.4	0.4	0.5	2.1	1.8	0.6	0.5	0.5	0.2	0.0
Chinkiang	0.4	0.2	0.5	0.7	0.6	1.6	1.5	1.5	1.0	0.3	0.3	0.0
Hankow	0.2	0.4	0.6	1.5	1.8	2.0	1.9	1.0	0.6	0.6	0.4	0.1

[1] *Suen, S. T.* The causes of rainfall and floods in China. Chinese Students' Monthly, Ithaca, N. Y., Mar. 1915, no. 6, 10:365-377, with 3 figures.

TABLE 2.—*Mean annual numbers of storms accompanied by more than 1 inch of rain.*

Stations.	Record.	1-2 inches.	2-3 inches.	3-5 inches.	5-7 inches.	7-10 inches.	10 inches and over.	Annual total.
	Years.							
Tamingfu	5	2.0	1.2	1.2			0.2	4.6
Weihweifu	5	1.4	0.4	0.8	0.2	0.2	0.4	3.8
Hokiu	8	2.6	2.2	1.5	0.5		0.3	7.1
Chinkiang	22	4.3	2.0	1.3	0.7	0.4	0.2	8.9
Hankow	22	4.7	2.4	2.0	1.1	0.5	0.3	11.0

Floods are thus the direct result of abnormal conditions as to rainfall. Ordinary floods may be defined as those to be expected two or three times in 10 years, while extraordinary floods come but once or twice in a century. The study of flood frequencies leads to that of storm frequency and Mr. Suen presents his results in Tables 1 and 2.—C. A. jr.

MEAN LAKE LEVELS DURING MAY, 1916.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., June 5, 1916.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during May, 1916:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	603.00	580.49	572.87	247.13
Above or below—				
Mean stage of April, 1916	+0.62	+0.57	+0.45	+0.73
Mean stage of May, 1915	+1.39	+0.87	+1.19	+1.98
Average stage for May, last 10 years	+1.14	−0.08	+0.14	+0.33
Highest recorded May stage	−0.05	−3.03	−1.55	−1.82
Lowest recorded May stage	+2.18	+0.93	+1.56	+2.17
Average relation of the May level to:				
April level	+0.3	+0.3	+0.3	+0.4
June level	−0.3	−0.2	−0.1	−0.1

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR MAY, 1916.

By W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., June 30, 1916.]

TABLE 1.—*Non-instrumental earthquake reports, May, 1916.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1916.	H. m.		° ′	° ′			M. s.			
2	14 28	Camp Baldy	34 15	117 40		1				C. T. McCulloch.
	14 28	Claremont	34 07	117 44		2	0 1			S. H. Brackett.
	14 28	Los Angeles	34 03	118 15	3	1	5			U. S. Weather Bureau.
3	0 30	Salinas	36 36	122 40						Ruth Abbott.
25	4 23	Brawley	32 59	115 40		1				M. D. Witter.
		IDAHO.								
13	1 00	Elk City	45 48	115 25	3	1	0 1		A distinct rock	Richard E. Moses.
	2 00	Lowman	44 08	115 41	2	1	8			Joseph Robertson.
	2 35	Idaho City	43 34	115 58	5	2	2			A. G. Stockes.
	2 35	Loon Creek	44 17	114 42	3	1	10			Allan Williams.
14	5 30	Elk City	45 48	115 25	3	1	1		A distinct rock	Richard E. Moses.
26	6 36	Boise	43 37	116 14	3	2	4			U. S. Weather Bureau.
	6 36	Idaho City	43 34	115 58	5	2	2			Jess Cullison.
	6 36	Payette	44 05	116 56	4	1	2	Rattling		E. F. Allen.
		ILLINOIS.								
21	18 24	Cairo	37 00	89 10	3	1	0 5			J. F. McGruder.
		MISSOURI.								
21	18 45	New Madrid	36 35	89 32	4	1	0 1	Rumbling		Josie G. Smith.
		WISCONSIN.								
31	22 45	Madison	43 05	89 21	2	2	0 20			Mrs. Eric R. Miller.
		PORTO RICO.								
13	6 00	Aibonito	18 08	66 17	5	2				D. Jordan.
14	13 25	Aibonito	18 08	66 17	5	1				D. Jordan.

TABLE 2.—*Instrumental reports, May, 1916.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see REVIEW for January, 1916, p. 39.]

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat. 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E — V 10, T_0 16.7; N — V 10, T_0 15.4

(No earthquakes recorded in May, 1916.)

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat. 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E — V 10, T_0 16; N — V 10, T_0 19.6

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			H. m. s.	Sec.	μ	μ	Km.	
May 11		P_E	10 07 14	4				Times on N doubtful.
		P_N	10 08 11	3				
		L_E	10 08 40	10				
		M_E	10 08 58	11	380			
		L_N	10 09 20	9				
		M_N	10 09 34	10		230		
		C	10 17 00	8				
		F_E	10 30 00	8				
		F_N	10 51 00	6				
26		L_E	21 01 50	10				Barely perceptible on N.
		M_E	21 03 43	6	20			
		C_E	21 04 27					
		F_E	21 08 00	6				

California. *Berkeley. University of California.*

Lat. 37° 32′ 16′ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			H. m. s.	Sec.	μ	μ	Km.	
May 3					*100	*200		Light tremors recorded during 24 hours preceding 3 p. m. on dates given.
7					*200	*200		
9					*100	*100		
17					*100	*100		
27					*100	*100		

*Amplitude on instrument.

California. *Santa Clara, University of.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.

(*See* Record of the Seismographic Station, University of Santa Clara.)

TABLE 2.—*Instrumental reports*—Continued.

Colorado. *Denver. Sacred Heart College. Earthquake Station.* A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 7		L	17 00 00					Wavelets on both components.
		F	17 16 00					Doubtful as to being seismic.
8		L	3 10 00					Small tremors and trailers on both components.
		F	3 25 00					
9								Activity and microseisms at intervals during day.
13		L_N	2 25 00					Preliminaries not visible. Record very small and indistinct. Time somewhat doubtful—Montana, Idaho, Washington.
		F_N	2 31 00					
17		L_N	5 10 00					Faint irregularities and wavelets.
		F_N	7 25 00					
20		L_E	18 40 00					Irregular waves.
		M_E	18 43 00					
		F_E	18 47 00					
20		L_E	21 28 00					Faint trailers.
		F_E	21 34 00					
20		L_N	20 26 00					Activity — microseisms.
		F_N	20 35 00					

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W.; Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. V 110, T_0 6

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10		P	21 43 07					
		S	21 48 08					
		L?	21 51 05	20				
		F	22 40 00					
11		P	10 10 35					Phases uncertain.
		S	10 17 45					
		L	10 21 00					
		F	11 00 00					
26		e	21 12 00					Phases uncertain.
		L	21 13 50					
		F	21 30 00					

District of Columbia. *Washington. Georgetown University.*
F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants:	V	T_0	ε
E	165	5.4	2.6
N	143	5.2	3.4
Z	*80*	*3.0*	*0*

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10	III_r	e	21 42 25					No distinct M.
		S_E	21 48 08					
		S_N	21 48 11					
		L_E	21 52 42	28				
		L_N	21 53 48	17				
		F	22 40 00					
11	III_r	iP	10 16 44					No distinct M. Microseisms. i for P seems quite cercertain. Vertical shows e_Z at $10^h 18^m 16^s$.
		S_N	10 21 01					
		S_E	10 21 05					
		eL_N	10 22 23					
		eL_E	10 22 29					
		F	10 38 00					
13	III_r	e_N	2 33 02					Heavy microseisms. Possibly S with P lost.
		e_E	2 33 12					
		e	2 41 50					
		F	2 58 00					

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instruments: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.9

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 3		eP	4 43 00					
		eS	4 53 00					
		L	5 03 30	23				
		M	5 09 00		*500			
		C	5 13 48					
		F	5 26 24					
7		e	5 57 48					
		L	6 08 12					
		M	6 10 54		*200			
		C	6 15 12					
		F	6 18 48					
7		eL	11 50 06					
		M	11 57 24		*200			
		C	12 01 00					
		F	12 13 24					
9		eL	15 34 42					
		M	15 40 06		*200			
		C	15 43 24					
		F	16 08 18					
10		P	21 57 42					
		L	22 09 48	24				
		M	22 15 30		*250			
		C	22 19 30					
		F	23 11 12					
11		e	10 24 06					
		L	10 24 54	24				
		M	10 28 06		*800			
		C	10 31 54					
		F	10 46 48					
26		P	2 10 00					
		L	2 18 18	22				
		M	2 21 30		*200			
		C	2 25 24					
		F	2 37 24					

* Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants..	V	T_0	ε
E	177	3.4	4.0
N	205	3.4	3.8

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 11		P	10 08 38	2–3				
		S?	10 12 15	6–9				
		L_N	10 14 26					
		L_E	10 14 28					
		M_N	10 15 35			20		
		M_E	10 15 39	9–12	23			
		F	10 51 00					
26		P	21 06 32					
		L?	21 07 42					
		M_E	21 08 34		1			
		M_N	21 08 39	8–10		1		
		F	21 16 00					

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants..	V	T_0
E	10	31
N	10	29

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10		S_E	21 48 05	6				Phases uncertain on N.
		eL_E	21 50 55	30				
		M_E	21 54 03	21	120			
		M_N	21 55 13	20		20		
		C_E	21 57 46	18				
		F_E	22 17 00					
11		e_N	10 18 20					No well-defined phases.
		e_E	10 19 48					
		S_E	10 21 17					
		S_N	10 21 29					
		M_N	10 21 39	10		20		
		L_E	10 23 50	8				
		M_E	10 24 01	10	10			
		C_E	10 25 00					
		F_E	10 30 00					

TABLE 2.—*Instrumental reports*—Continued.

Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.

Lat. 42° 22′ 36″ N.; long. 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

		V	T_0	ϵ:1
Instrumental constants..	E	80	23	0
	N	50	25	4:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 3	....	L_E....	5 38 43	20	......	......	......	Undamped record. Not registered on N, damped 4/1. A increases slightly.
		L.....	5 47 43	20	......	......	......	
		F.....	6 00 00	....	......	......	......	
4	....	....	....	....	......	......	......	11h 3m probably local disturbance.
9	....	e?.....	14 01 15	8-9	......	......	......	E component ran down between 7d 15h 9m and 8d 13h 50m.
		L_E?...	14 04 37	10	......	......	......	
		L_E?...	14 06 28	....	......	......	......	
		F?....	14 20 00	....	......	......	......	
10	....	*O*.....	*21 37 20*	....	......	......	3,420	
		eP_E...	21 44 04	2	......	......	......	
		i_N....	21 44 26	3	......	......	......	
		e_E....	21 46 58	6	......	......	......	
		S_E....	21 49 16	12	......	......	......	
		eL_N...	21 53 54	....	......	......	......	
		eL_E...	21 54 03	28	......	......	......	
		L_N....	21 56 40	20	......	......	......	
		M_E....	21 57 16	20	......	......	......	
		L.....	22 06 24	8	......	......	......	
		F_E....	22 48 00	....	......	......	......	
11	....	*O*.....	*10 00 00*	....	......	......	......	Press reports shock felt at Houghton, Mich., U. S. A., during night. *ca. φ 47° 9′ N. λ 88° 33′ W. Hour not reported. N pendulum moved east. E undamped. A?
		eP_N...	10 21 08	....	......	......	......	
		S_N....	10 23 30	....	......	......	......	
		S_E....	10 23 31	10	......	......	......	
		eL_E...	10 24 38	13	......	......	......	
		eL_N...	10 24 47	....	......	......	......	
		M_E....	10 26 51	14	......	......	......	
		L_E....	10 27 01	10	......	......	......	
		L_E....	10 28 07	6-8	......	......	......	
		F.....	11 20 00	....	......	......	......	
14	....	S_E?...	5 32 37	6	......	......	2,650?	eP? 5h 29m 56s. L very faint on N.
		eL_E...	5 34 36	18	......	......	......	
		....	....	15	......	......	......	
		F.....	5 43 00	....	......	......	......	
17	....	*O*?....	*18 00 00*	....	......	......	7,000?	Δ and *O* uncertain. Much masked by microseisms of 3 secs. period. Time uncertain: plus or minus 6 secs. F lost in microseisms.
		S?.....	18 24 01	....	......	......	......	
		i_E.....	18 30 24	9	......	......	......	
		eL....	18 35 45	30	......	......	......	
		L(M) .	18 39 11	25	......	......	......	
		F?....	18 48 00	....	......	......	......	
26	....	L_E?...	{21 17 16 21 20 00}	8	......	......	......	Maximum A among microseisms? Period 3 secs. on N damped 4/1.

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

	V	T_0	ϵ:1
Instrumental constants..	80	7	5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 11	II_r.....	eP....	10 13 00	....	......	......	1,700	
		S......	10 15 49	....	......	......	......	
		L......	10 16 11	....	......	......	......	
		F......	10 25 00	....	......	......	......	

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

	V	T_0	ϵ:1
Instrumental constants..	80	7	5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10	....	eP....	21 42 45	....	......	......	......	
		S_E....	21 48 30	....	......	......	......	
		S_N....	21 48 35	....	......	......	......	
		L_E....	21 52 00	30	......	......	......	
		L_N....	21 53 30	....	......	......	......	
		F.....	22 19 00	....	......	......	......	
11	....	eP_E...	10 16 20	....	......	......	......	
		S_N....	10 20 05	....	......	......	......	
		S_E....	10 20 10	....	......	......	......	
		M_N....	10 22 10	10	......	......	......	
		M_E....	10 22 20	10	......	......	......	
		F.....	10 52 00	....	......	......	......	

New York. *Fordham. Fordham University.* W. C. Repetti, S. J.

Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert, 80 kg.

		V	T_0	ϵ:1
Instrumental constants..	E	72	7.2	1.5:1
	N	72	7.2	3.8:1

(Report for May, 1916, not received.)

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

		V	T_0	ϵ
Instrumental constants..	E	13	22	4:1
	N	14	25	4:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10	....	e_E.....	21 50 50	9	......	......	......	Microseisms.
		L_E....	21 54 06	27-12	......	......	......	
		eL_N...	21 55 59	22-12	......	......	......	
		F_E....	22 03 30	....	......	......	......	
		F_N....	22 09 00	....	......	......	......	
11	....	e_E.....	10 20 50	15-7	......	......	......	Microseisms.
		e_N.....	10 21 02	17-6	......	43	......	
		F_N....	10 33 00	....	......	......	......	
		F_E....	10 34 00	....	......	......	......	

Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long. 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori 100 kg.

	V	T_0
Instrumental constants..	10	20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 3	....	P_E....	17 20 55	....	......	......	483	Probable direction NW. No record on N-S, clock stopped. Amplitude unknown, earthquake and blast record combined.
		S_E....	17 21 31	....	......	......	......	
		L_E....	17 21 55	....	......	......	......	
		M_E....	17 22 00	....	120	......	......	
		F_E....	17 26 30	....	......	......	......	
10	....	P_E....	21 37 17	....	......	......	386	Probable direction NW.
		P_N....	21 37 20	....	......	......	......	
		L_E....	21 38 05	....	......	......	......	
		L_N....	21 38 06	....	......	......	......	
		M_E....	....	....	8500+	......	......	M, pen off sheet.
		M_N....	....	....	......	8700+	......	
		F_E....	21 54 45	....	......	......	......	
		F_N....	22 00 00	....	......	......	......	
13	....	P.....	7 38 35	....	......	......	298	Probable direction NW.
		L.....	7 39 11	....	......	......	......	
		M_E....	7 39 19	....	......	......	......	
		M_N....	7 39 20	....	......	50	......	
		F_E....	7 40 30	....	......	......	......	
		F_N....	7 42 10	....	......	......	......	
14	....	P_N....	0 07 50	....	......	......	507	Probable direction NW.
		P_E....	0 07 55	....	......	......	......	
		L_N....	0 08 54	....	......	......	......	
		L_E....	0 09 00	....	......	......	......	
		M_N....	0 09 10	....	......	240	......	
		M_E....	0 09 20	....	150	......	......	
		F_E....	0 17 25	....	......	......	......	
		F_N....	0 17 30	....	......	......	......	

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

		V	T_0
Instrumental constants..	E	10	21.4
	N	10	21.1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10	....	P_N....	21 41 11	6	......	......	......	
		P_E....	21 41 17	....	......	......	......	
		S_N....	21 44 43	6	......	......	......	
		S_E.....	21 44 49	....	......	......	......	
		eL_E...	21 48 33	18	......	......	......	
		M_E....	21 49 20	18	10	......	......	
		M_N....	21 53 30	14	......	10	......	
		F.....	22 07 00	....	......	......	......	
13	....	P_N....	5 23 30	....	......	......	......	Felt in San Juan. Time-marking device out of order on N.
		P_E....	5 23 42	....	......	......	......	
		L_E....	5 24 02	....	......	......	......	
		M.....	5 24 09	....	300	120	......	
		F_E....	5 30 48	....	......	......	......	
13	....	P_N....	6 34 32	....	......	......	......	Felt in San Juan.
		P_E....	6 34 46	....	......	......	......	
		M.....	6 35 03	....	70	50	......	
		F.....	6 40 00	....	......	......	......	

TABLE 2.—*Instumental reports*—Continued.

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. { E: V 10, T_0 15; N: V 10, T_0 16 }

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 10		eP?	21 44 16					S and L lost through changing of sheets.
		F	22 30 00					
11		e?	10 10 00					
		L	10 23 20					
		F	11 00 00					
26		e	2 15 45					
		F	2 30 00					
26		e?	21 12 26					
		L	21 16 30					
		F	21 30 00					

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants: V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 9		{ L_E	15 53 00	} 18				
		{ L	15 56 00					
		L	16 38 00	40				
10		*O*	*21 36 53*				3,910	
		P_N	21 44 04					
		S_E	21 49 46					
		L_N	21 53 18	20				
		L_E	21 53 42	40				
		L_E	21 57 00	20				
		L	22 00 00	15-16				
		L_E	22 05 00	12				
		L_N	22 11 00	13				
		F	22 45 00					
11		e	10 20 12					
		eL	10 22 12					
		M	10 22 42	6	110	270		
		L	10 30 00	6				
		L_E	10 47 00	8				
		F	11 00 00					
14		L	{ 0 26 00 0 35 00 }	} 20-14				
17		L	13 18 18	26				
		L	13 21 00	20				
		L	13 26 00	16				
		L	13 28 00	14				
		L	13 31 00	10				
		F	13 40 00					
26		e_N	2 17 00					
		L_E	2 22 30	20				
		F	2 40 00					
26		i	21 13 30					
		i_N	21 14 42					
		L_E	21 15 12	14				
		L_E	21 17 00	10				
		L_E	21 20 00	7				
		F	21 30 00					

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 3		L	5 42 12					
		F	6 00 36		*200			
9		L	15 53 24					
		L	15 58 30		*50			
		F	16 21 24					
10		P?	21 44 30					Marked quake.
		S_E	21 49 36					
		i	21 52 36					
		L	21 53 42					
		i	21 55 18					
		L	21 56 06					
		M	22 00 48		*3400			
		F	22 48 06					
11		i	10 21 36					Very abrupt beginning. Vibrations gradually decreased after the maximum
		L	10 21 54					
		M	10 22 24		*1600			
		F	10 52 24					
14		e	0 32 00					
		L?	0 39 48					
		F?	0 46 00		*50			
17		e	13 22 24					
		L	13 27 42		*100			
		F	13 41 12					
26		L	21 13 30					
		F	21 18 30		*200			

* Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Wiechert, vertical: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
May 3		P?	5 23 07				4,200?	
		S	5 29 05					
		M	5 35 31		*100			
		F	?					
10		P	22 06 58				2,390	
		S	22 10 54					
		L	22 13 22					
		M	22 17 08		*200			
		F	22 35 29					
11		P?	10 16 54				870?	
		L	10 18 28					
		M	10 20 27		*600			
		F	10 27 07					
				VERTICAL.				
					A_Z			
		L?	*10 18 28*	*8-10*	*3*			
		M	*10 20 03*	*8-10*				
17		L?	13 34 11					
		M	13 35 41		*100			
		F	13 38 11					
26		L	2 19 46					
		M	2 21 45		*100			
		F	?					

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.[1]

San Jose, Costa Rica, May 1, 1916.

Twenty distinct shocks occurred here today while the people of the capital were in the midst of the first of May festival. A number of buildings, including churches and schools, were demolished. The people fled to the streets and squares, fearing the city was about to be destroyed. (*Assoc. Press.*)

Los Angeles, Cal., May 2, 1916.

A slight earth shock lasting five seconds occurred here today at 6:30 o'clock, a. m., according to Dr. Ford A. Carpenter, Forecaster of the Weather Bureau. The movement, he said, was from west to east. (*Assoc. Press.*)

New York, May 4, 1916.

Only slight damage was caused by the earthquake shocks of April 30 in Costa Rica, according to wireless reports and private telegrams received here to-day by the United Fruit Co. The subsequent interruption of telegraphic communication between Costa Rica and Salvador, as announced in a cable dispatch received yesterday from San Salvador, was due to static conditions arising from heavy storms, according to the company's advices to-day, and not to the earth shocks. (*Assoc. Press.*)

Boise, Idaho, May 12, 1916.

This city experienced an earthquake at 7:26 o'clock to-night which lasted about three seconds. People rushed in to the streets. Several brick chimneys were wrecked. The tremor was not felt to the east of Boise. Twenty-five miles north, at Emmett, the quake was violent and alarmed the inhabitants. Nanpa, to the south, also felt the shock, as did Idaho City, 36 miles north. At Weiser, 60 miles west, the quake was of exceptional violence. A new gas well, in which a flow was struck 10 days ago, showed remarkable increase of pressure immediately after the shock. From irrigated sections came reports that canals had been damaged, but not beyond repair. An earthquake last fall split a deep seam across the New York Canal, one of the largest in Idaho and it required weeks to repair it. (*Assoc. Press.*)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University, Washington, D. C.

Reno, Nev., May 12, 1916.

The seismograph at the Mackay Schools of Mines, University of Nevada, registered an earthquake at 6:31 o'clock to-night. The disturbance lasted until 6:36 p. m. (*Assoc. Press.*)

Anaconda, Mont., May 12, 1916.

An earthquake shock was felt here at 7:30 o'clock to-night. Buildings were shaken but no damage was done. (*Assoc. Press.*)

Spokane, Wash., May 12, 1916.

The seismograph at Gonzaga University here registered a pronounced earthquake shock at 6:39 o'clock to-night, followed by several smaller ones, the entire disturbance lasting about 15 minutes. The general direction of the tremble was southeast to northwest, the main shock being unusually severe for this region, it was stated. The quake occurred about 80 miles southeast of Spokane. (*Assoc. Press.*)

Rome, May 17, 1916 (via Paris, May 18, 1916, 11:15 a. m.).

An earthquake of particular violence has occurred along the Adriatic coast between Rimini and Cesena. At the latter town a dozen people were injured by the fall of cornices.

The entire central section of Italy was shaken by repeated earthquakes which lasted through Tuesday and Wednesday. Only the most meager details have as yet been received in this country and it is not known what loss of life occurred, if any. (*Assoc. Press.*)

Rimini, Italy, May 19, 1916, 11:20 a. m.

Serious damage was done here by the earthquake which shocked central Italy during the night of May 16-17. Ten houses collapsed and about a thousand dwellings were damaged. The municipal theater and the underprefecture school buildings were cracked to an alarming extent, and part of the church of Colonnella has fallen. (*Assoc. Press.*)

Honolulu, May 20, 1916.

Mauna Loa in eruption and Kilauea unusually active. (*Honolulu Weather Bureau.*)

Willemstad, Curaçao, May 27, 1916.

A heavy earth shock was felt throughout this island at 2:30 o'clock this afternoon. No damage has been reported. (*Assoc. Press.*)

Baker, Oreg., May 28, 1916.

A slight earthquake which shook eastern Oregon, flooded part of the Baker Country Club golf links with a spring which burst forth within a few hundred yards of a mineral spring. Although the water in the mineral spring is hot, the spring flows ice cold. (*Internat. News Ser.*)

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological and seismological work and studies:

Abbot, C. G., *and* Aldrich, L. B.
The pyranometer—an instrument for measuring sky radiation. Washington. 1916. 2 p. l., 9 p. Tables, diagrs. 24½ cm. (Smithsonian miscellaneous collections. vol. 60, no. 7.)

Abbot, C. G., Fowle, F. E., *and* Aldrich, L. B.
On the distribution of radiation over the sun's disk and new evidences of the solar variability. Washington. 1916. 4 p. l., 24 p. tables, diagrs., plate. 24½ cm. (Smithsonian miscellaneous collections. vol. 66, no. 5.)

Annuaire astronomique et météorologique.
52e année, 1916. Par Camille Flammarion. Paris. n. d. 431 p. 18½ cm.

Annuario scientifico ed industriale.
Anno 52, 1916. Milano. 1916. 4 p. l., 509 p. tables, diagrs. 19½ cm.

Bouyoucos, G. J.
Soil temperature. East Lansing. 1916. cover-title, 133 p. tables. 23½ cm. (Michigan agricultural college experiment station. Division of soils. Technical bulletin. no. 26.)

British association for the advancement of science.
Report of the 85th meeting, Manchester. 1915. London. 1916. lxviii, 840, 103 p. plates, tables, diagrs. 22 cm.

Carpenter, F. A.
Clouds of California. May-Day address, Occidental college. 2d ed. Fort Leavenworth. 1916. 18 p. 24 cm.

Denmark. Meteorologiske institut.
Meteorologisk aarbog. 1ste del: Kongeriget Danmark, 1914. Kjøbenhavn. 1916. xii, 1 lf., 75 p. tables. 31 cm.

Frear, William.
Climatology of State College, Pa. Precipitation (rain or snow), 1880–1913. (*In* Annual report of the Pennsylvania State college, 1913–1914. Harrisburg. Pt. 2, p. 233–347. 23½ cm.)

Hopkinson, John.
The climate of Hertfordshire, deduced from meteorological observations for 25 years and rainfall observations for 70 years. n. p. 1913. p. 195–206. tables, diagr. 21½ cm. (Reprinted from the Transactions of the Hertfordshire natural history society. vol. 15, part 4. Jan., 1915.)

Livingston, B. E.
A single index to represent both moisture and temperature conditions as related to plants. Baltimore. 1916. cover-title, p. 421–440. tables, diagr. 26½ cm. (Physiological researches. vol. 1, no. 9.)

Longstreth, T. M.
Reading the weather. New York. 1915. 5 p. l., iv, 11–195 p. front., plates. 18 cm. (Outing handbooks, no. 43.)

Mexico. Instituto geológico.
Catálogos de los seismos registrados durante el año 1912 en la Estación seismológica central, Tacubaya; en las Estaciones seismológicas de primer orden de Mérida, Yuc. y de Zacatecas y en las de segundo orden de Oaxaca y de Mazatlán, Sin. Catálogo de los macroseismos sentidos en la República mexicana, 1912. Mexico. 1914. p. 229–349 incl. tables. 23 cm. (Mexico, Inst. geol. Parergones. vol. 5, nos. 6–8.)

Mexico. Instituto geológico.
Catálogos de los movimientos registrados durante el año 1911 en las estaciones seismológicas de Mérida, Yucatán, Mazatlán, Sinaloa y Coaxáca. Catálogo de los macroseismos sentidos en la República mexicana, 1911. Mexico. 1913. 79 p. incl. tables. 23 cm. (Mexico. Inst. geol. Parergones. vol. 5, nos. 1–3.)

Norris, F. E.
Third annual report of the seismograph station at Hill View, Woodbridge Hill, Guildford, England. Guildford. 1913. n. p. tables. 31 cm.

Pierce, W. D.
A new interpretation of the relationships of temperature and humidity to insect development. Washington. 1916. p. 1183–1191. tables, diagrs. 26 cm. (Reprint from the Journal of agricultural research. vol. 5, no. 25. March 20, 1916.)

Quayle, E. T.
A graphical method of showing the daily weather, and especially cloud types. Melbourne. [1916.] 2 p. l., 6 p. incl. diagrs. 31 cm. (Australia. Commonwealth bureau of meteorology. Bulletin no. 12.)

Southport, Fernley observatory.
Report and results of observations for the year 1915. Southport. 1916. 28 p. incl. tables. 24½ cm.

Taylor, Griffith.
The climatic control of Australian production. (An attempt to gauge the potential wealth of the commonwealth.) Melbourne. [1916.] 32 p. 43 diagrs. 31 cm.

Terada, T., Yokota, T., *and* Otuki, S.
On the distribution of cyclonic precipitation in Japan. Tokyo. 1916. 32 p. tables, diagrs. 26 cm. (Journal of the College of science, Tokyo imperial university. vol. 37, article 4.) [See abstract by Terada in this REVIEW, March, 1916, p. 127.]

Wicks, Moye.
Deforestation and reforestation as affecting climate, rain, and pro duction. Austin. [1915.] 11 p. 22½ cm. (Texas. Dept. of agriculture. Bulletin, n. s. no. 17.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American journal of science. New Haven. v. 41. June, 1916.
Very, Frank W. Fundamental distinctions special to the process of transmission of terrestrial radiation by the atmosphere, and the value which is obtained for the coefficient of transmission when these are considered. p. 513–521.

Astronomical society of the Pacific. Publications. San Francisco. v. 28. April, 1916.
Tucker, R. H. The diurnal variation of the refraction. p. 69–73.

British association for the advancement of science. Report. 85th meeting. Manchester, 1915. London. 1916.
Masson, Orme, & others. The influence of weather conditions upon the amounts of nitrogen acids in the rainfall and atmosphere in Australia. p. 87–94.
Whipple, F. J. W. The mechanism of cyclones. p. 367. [Abstract.]

British astronomical association. Journal. London. v. 26. March, 1916.
Backhouse, T. W. Atmospheric absorption. p. 231–237.

Japan. Imperial earthquake investigation committee. Bulletin. Tokyo. v. 8. no. 2. April, 1916.
Omori, F[usakichi.] The Sakura-jima eruptions and earthquakes. II. On the sound and ash-precipitation areas of, and on the level changes caused by, the eruptions of 1914, with historical sketches of earlier Sakura-jima outbursts. p. 35–179.

Journal of geography. Madison. v. 14. June, 1916.
Ward, Robert DeC[ourcy]. The weather factor in the great war. IV. October, 1915–February, 1916. p. 373–384.

Science. New York. v. 43. June 16, 1916.
McAdie, Alexander [G]. Thermometer scales. p. 854–855.

Soil science. New Brunswick, N. J. v. 1. January, 1916.
Lipman, C. B., & Waynick, D. D. A detailed study of effects of climate on important properties of soils. p. 5–48.

Scientific American. New York. v. 114. June 17, 1916.

What is sleet? p. 634. [Compare, this Review, p. 281.]

Terrestrial magnetism and atmospheric electricity. Baltimore. v. 21. June, 1916.

Störmer, Carl. Preliminary report on the results of the aurora-borealis expedition to Bossekop in the spring of 1913. (Fourth communication.) p. 45-56.

Nichols, E. H. Investigations with regard to the effect of the induced charge on the Ebert electrometer at Kew observatory. p. 87-99.

Swann, W. F. G. Reply to E. H. Nichols's article (Investigation with regard to the induced charge on the Ebert electrometer at Kew observatory.) p. 99-102.

Académie des sciences. Comptes rendus. Paris. Tome 162. 5 juin, 1916.

Galitzine, B. Sur la localisation de l'épicentre d'un tremblement de terre d'après les observations d'une seule station sismique. p. 878-880.

Annales de géographie. Paris. 25 annèe. 15 mars, 1916.

Tian-Chanskii, Semenof. Woeikof (A). p. 150-151. [Obituary. Abstract from Novoe Vremia. See this Review, p. 288.]

Archives des sciences physiques et naturelles. Genève. t. 41. 15 mars, 1916.

Margot, Charles. Modèle simplifié d'hygromètre à condensation. p. 222-225.T

Mercanton, Paul L. Les tirs grêlifuges. p. 257-258.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, July 3, 1916.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole, the mean barometric pressure was above the normal in the Pacific Coast States, Idaho, and the western portion of Montana, but for all other sections it was below the normal. The positive departures were generally small, the greatest values appearing in northern California and southwestern Oregon. Likewise the negative departures were not marked, they being greatest in the Canadian Provinces, east of the Rocky Mountains, and in Michigan, Minnesota, and portions of the Dakotas.

The month opened with relatively low pressure over the Lake region, in southern Texas, the extreme northern Rocky Mountain region, and the Pacific Coast States. Elsewhere it was near or somewhat above the normal. During the next few days the pressure was generally high, except that a low area moved from Texas northeasterly across the country and down the St. Lawrence Valley. During the next week a succession of rather extensive low-pressure areas moved easterly from the far northwest, causing relatively low pressure throughout most of the northern border States and the Canadian Provinces, while in the southern half of the country the pressure was relatively high most of the time. However, about the 12th of the month the conditions in the north were replaced by a rather extensive high-pressure area which continued for several days, and, at the same time, a low-pressure area of considerable magnitude moved slowly across central and eastern districts from the far southwest. During the latter half of the month a succession of rather extensive low and high pressure areas followed one another somewhat slowly across the country.

The month closed with relatively low pressure along the Atlantic and Gulf seaboards and over the Great Plains, Rocky Mountain, and Plateau regions, while high pressure prevailed over the Lake region, but elsewhere pressure was near the normal.

The distribution of highs and lows was favorable for southerly and southwesterly winds in New England, and the coastal portions of the Middle and South Atlantic States, except Florida, and over the western Gulf States, and most of the Great Central valleys. It was favorable for westerly and northwesterly winds in the lower Lake region, the upper Missouri Valley, and over much of the Pacific Coast States, while elsewhere variable winds prevailed.

TEMPERATURE.

During the first few days of the month cold weather with heavy to killing frosts occurred from western Nebraska northward over the Dakotas and in the western portions of Minnesota and Iowa. This area of cold weather spread across the central valleys and reached the Atlantic coast by the 4th, but in the meantime it had turned warmer over the Great Plains, and by the 6th warmer weather prevailed over most of the central regions, with temperatures above 80° in Montana and above 90° in western Nebraska and Kansas.

An area of colder weather overspread the Pacific Coast States on the 7th, when in parts of California the lowest temperature on record for May occurred. The temperature was moderately high in central districts on the 7th, and in the eastern sections on the 8th; but the area of colder weather from the Pacific coast overspread the northern Rocky Mountain States, and on the 8th heavy to killing frosts occurred in Montana and Wyoming, and light frosts in western Nebraska. On the 9th mostly fair and colder weather prevailed in the central valleys.

During the first nine days of the month there was a large deficiency in temperature over most of the country, especially in the extreme northern portions and in most of the Rocky Mountain and Great Basin States, where frosts and freezing temperatures were frequent.

About the beginning of the second decade fair and cool weather overspread the central and eastern parts of the country, when light frost occurred in southern and killing frost in northern New England. At the same time there was warmer weather over the Rocky Mountains, but another area of much lower temperature covered the Pacific Coast States and Plateau region. During the next few days this area of cold weather moved across the central and northern parts of the country, accompanied by heavy to killing frosts in the interior of Oregon and Washington, the northern Rocky Mountain States and to the eastward. The somewhat warmer weather which followed was quickly replaced by another area of cold accompanied by general frosts and freezing temperatures over the Rocky Mountain and portions of the Plains States.

About the 16th unseasonably low temperatures prevailed in the lower Lake region and Ohio Valley and eastward to the Atlantic coast, and during the next few days cool weather and frosts were general over the Northwest, extending southward to central Nebraska and Kansas. This cold area spread eastward, reaching the Atlantic coast about the 20th, with general frosts in the upper Lake region, the Ohio Valley, and central Appalachian Mountain region as far south as West Virginia and Kentucky.

The last decade of the month opened with cold weather in the far Northwest and western Plateau district, with temperatures below freezing in Nevada and light frosts in parts of California. There was a general rise in temperature as the decade progressed in most central and eastern districts, but over the Rocky Mountain and Plateau States it continued low, and frosts and freezing weather were general. The temperature during the last week of the month was considerably above the normal in most central and eastern parts of the country, but it continued much below normal in the Rocky Mountain,

Plateau, and Pacific Coast States. Temperature was below freezing in portions of the Plateau and Rocky Mountain regions, 20° being recorded at Flagstaff, Ariz., on the 26th, while 90° or above occurred in most of the central and southern parts of the country, and in a few of the Southern States the previous maximum for May was equaled.

For the month as a whole the mean temperature was above the normal in all sections south of northern Massachusetts and northern Pennsylvania and from the lower Lake region southwesterly to southern New Mexico, except over the southern half of the Florida Peninsula, and locally in Texas, Ohio, and Indiana; elsewhere it was below the normal.

RAINFALL.

The month opened with rain in the central parts of the country, and during the next few days precipitation occurred from Texas and the lower Mississippi Valley northeastward to the Great Lakes. The rainfall was heavy in the lower Mississippi Valley and excessive in parts of Louisiana and Mississippi. Fair weather prevailed over most of the country on the 5th, but on the 6th rain fell on the north Pacific coast and from the Lake region and Ohio Valley eastward, with fair weather in practically all the Central and Southern States. Showers occurred on the 9th in the Northeastern States, on the Pacific coast, and in extreme southern Georgia and northern Florida.

About the beginning of the second decade scattered showers occurred in the northern part of the country, and general rains fell from Wyoming eastward to the Ohio Valley, with light showers over most of Florida, relieving the drought in the central and southern counties of that State.

About the middle of the month general and widespread rain fell in much of the central and northern parts of the country, and rain continued in central and northern Florida, extending northward along the Atlantic coast. The amounts were heaviest in the lower Missouri and the central and eastern Mississippi Valleys, but practically none had fallen throughout all the southern portions of the Rocky Mountain and Plateau regions and over much of the Pacific Coast States.

Near the close of the second decade general rains occurred in the Gulf States, Oklahoma, and Kansas, while light, scattered falls were reported from north-central California and to the northward over Oregon and Washington.

The precipitation for the seven-day period ending May 23 was very unevenly distributed. It was excessive in some parts of Texas and in the lower Mississippi Valley, and damaging local rains occurred in New York and New England, while general rains fell over the corn and wheat States and also the greater part of the cotton region. Light, scattered showers occurred in parts of California and in extreme southern Texas, and the drought was checked in most of the Southeast by general rains.

The last week of the month opened with general rains along the Atlantic coast from Florida to southern New England, the falls being heavy in parts of the Carolinas. Rain was reported also in scattered areas of limited extent in the corn and wheat regions, as well as over the northern Rocky Mountain district. During the next few days scattered rains occurred in the Northwestern States, some of the precipitation in the Rocky Mountains coming in the form of snow. However, in the southern part of the country there was very little rainfall until after the middle of the week, and then it was confined largely to the eastern Gulf States, Oklahoma, and Arkansas. During the last few days of the month general showers occurred in Florida and in the lower Missouri and central Mississippi Valleys, and from northern Alabama northeastward over the Ohio Valley, the Lake region, and the Northeast, the falls being heavy in parts of Tennessee. The heaviest rain during this period occurred in central Missouri, where over 4 inches fell, but it was moderate to heavy in nearly all the central parts of the country, as well as in central Montana. Little or no rain fell in the coastal portion of the west Gulf States, the southern portions of the Rocky Mountain and Plateau regions, and the Pacific Coast States. Some damage was done by local storms in the northern part of the country.

For the month, as a whole, the rainfall was heavy in Mississippi, Louisiana, and eastern Texas, in portions of Kansas, Iowa, Missouri, and Illinois, and over small areas in Tennessee, North Carolina, Virginia, Maine, Minnesota, and South Dakota. Elsewhere it was moderate to light, except in extreme southwest Texas and the southern portions of Arizona and California, where little or no rain fell.

GENERAL SUMMARY.

For the month, as a whole, the weather was generally favorable for the growth of vegetation and the advancement of field crops in practically all central and most eastern districts. In the Northeast and North Central States, Rocky Mountain, Plateau, and Pacific coast districts crops were retarded by the cold weather, while in some southern and southeastern sections it was too dry for best results.

Corn planting, its germination and growth were retarded by dry weather in southeastern States and wet and cold conditions in the northern districts during much of the month. However, during the last week there was a decided improvement in nearly all parts of the country. The weather was generally favorable for the growth and development of winter wheat, except that it was too dry in parts of the Southeast and Southwest, and some damage resulted from frost and cold in the Rocky Mountain and Plateau districts and north Pacific States. Spring wheat progressed favorably, although growth was somewhat retarded by the cold weather.

Much cotton seed failed to germinate well, and a generally poor stand was reported in the early part of the month because of the cold and dry weather. However, the warm weather and rains later in the month had a very favorable effect, and there was a decided improvement and rapid development of the crop. Truck crops generally made favorable progress, except somewhat damaged by drought in the Southeast and by frosts and unseasonably cold weather from the Rocky Mountain States westward.

The condition of fruits was generally favorable, except some damage resulted from the cold weather and frost in portions of the Rocky Mountain and Plateau districts, the damage being rather extensive in parts of Idaho and Utah.

LOCAL STORMS.

The following notes on severe storms have been extracted from reports of Weather Bureau officials:

Texas.—A thunderstorm visited Dallas and Kaufman Counties during the evening of May 15, 1916, the wind

reaching a velocity of 40 miles an hour about 9:30 p. m., with an unusually heavy downpour of hail from 9:31 to 9:36 p. m., covering the ground like a blanket of snow. Some of the hailstones were from one-half to 1 inch in diameter. In places corn and vegetation were stripped of blades and leaves, cotton was beaten into the ground, and fruit and other trees damaged. One person was killed by lightning near Terrell, Tex., and crops and property damage was estimated at over $50,000.

Alabama.—A severe storm occurred shortly after midnight of May 21–22, 1916, about 6 miles south-southwest of Birmingham, Ala. Several mining camps with the homes of the employees were in the direct path of the storm, which was about 500 feet wide and a mile in length. The first damage was the blowing over of three steel towers bearing high-tension wires. At one of the camps (Spring Gap) one house was destroyed and its three occupants (a woman and two children) were killed. Several other houses were blown so that they leaned from 15 to 20° in a northwesterly direction, but retained their foundation positions. Boards, pieces of tin, and other loose material were carried several hundred yards to the northwest, and many trees were blown over, about half the latter being snapped off a few feet above the ground. Besides the three people killed several were injured, one severely. Property loss was about $15,000.

South Carolina.—A severe storm visited Charleston, S. C., on the afternoon of May 30, 1916. All wreckage fell in one direction, which indicates it was not a tornado. The storm traveled from west to east, and was about 150 yards wide and less than one-half mile in length. The property damage was slight, being confined principally to the demolition of some advertising signs, the blowing over of a few chimneys, and wrecking a portion of the roof of the Union Station. One man was struck and killed by an advertising sign behind which he had apparently taken refuge, and a boy was seriously injured in the same way.

Average accumulated departures for May, 1916.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	0–10		Per ct	
New England	54.4	−0.1	− 4.4	3.69	+0.30	−2.20	6.3	+0.8	74	−4
Middle Atlantic	63.6	+8.0	+ 7.9	3.40	−0.10	−1.50	5.4	+0.4	65	−7
South Atlantic	72.8	+3.0	+ 9.6	2.48	−1.30	−8.60	4.2	−0.3	68	−6
Florida Peninsula	77.0	−0.2	− 1.3	3.46	−0.80	−5.90	5.1	+0.7	76	0
East Gulf	74.5	+2.2	+ 6.7	5.04	+1.50	−7.00	3.6	−1.1	67	−4
West Gulf	73.4	+0.5	+ 8.7	4.27	+0.60	−1.80	4.5	−0.3	73	−2
Ohio Valley and Tennessee	66.7	+1.5	+ 1.8	3.93	+0.20	−0.90	5.4	+0.4	65	−3
Lower Lakes	57.0	−0.5	− 2.9	4.14	+1.00	+1.60	5.9	+0.5	71	0
Upper Lakes	52.6	−0.1	− 2.7	3.61	+0.30	+1.20	6.1	+0.6	70	−2
North Dakota	51.7	−2.6	−13.5	2.20	−0.30	+0.20	5.3	−0.2	62	0
Upper Mississippi Valley	62.0	−0.1	+ 0.4	4.49	+0.30	+0.90	5.8	+0.5	67	−1
Missouri Valley	61.7	−0.3	+ 0.2	4.18	0.00	−2.80	4.8	−0.3	65	0
Northern slope	49.3	−3.7	− 7.5	2.30	−0.10	−0.80	5.5	0.0	60	+2
Middle slope	62.8	−0.2	+ 1.6	2.33	−1.10	−1.90	4.4	−0.5	58	−3
Southern slope	71.4	+0.8	+13.3	1.54	−1.20	−2.00	3.1	−1.3	49	−8
Southern Plateau	64.5	−1.4	+ 2.4	0.10	−0.20	+1.60	1.6	−1.1	31	−1
Middle Plateau	53.5	−3.0	+ 1.9	0.50	−0.60	0.00	3.4	−0.7	38	−8
Northern Plateau	51.9	−5.0	− 7.7	1.50	−1.20	+0.90	6.0	+0.9	58	+2
North Pacific	51.6	−2.3	− 6.2	1.81	−0.40	−5.10	6.3	0.0	74	−2
Middle Pacific	56.1	−1.5	+ 3.3	0.38	−0.90	+0.10	2.9	−1.1	62	−9
South Pacific	60.7	−0.9	+ 3.9	0.02	−0.60	+4.60	2.8	−1.3	65	−4

WEATHER CONDITIONS ON THE NORTH ATLANTIC DURING MAY, 1915.

The data presented are for May, 1915, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. Chart IX (XLIV–63) herewith shows for May, 1915, the averages of pressure, temperature, and the prevailing direction of the wind at 7 a. m., 75th Meridian time, together with the locations and courses of the more severe storms of the month.

PRESSURE.

The distribution of the average pressure for the month, as shown on Chart IX, differed in many respects from the normal. The Azores HIGH, with a crest of 30.1 inches, was near its usual position and extended from the 22d to the 29th parallels and the 29th to the 58th meridians. No traces of the Icelandic LOW could be seen, and a HIGH with a crest of 30.1 inches was central near latitude 60° N., longitude 5° W. A LOW of 29.7 inches and of small extent was located with its center about three degrees east of St. Johns, Newfoundland, while there was no sign of the usual continental HIGH over the eastern districts of the United States. The pressure over the position normally occupied by this area was remarkably uniform, ranging from 29.9 to 30 inches. One of the most unusual features of the barometric distribution was the high pressure that prevailed over the northern portion of the ocean during the greater part of the month. The lowest individual barometric reading during the month in the region between the 60th and 65th parallels and the 15th and 20th meridians was 29.6 inches, occurring on May 3 and again on the 4th, while readings as high as 30.57 inches occurred in this region on May 8, and the average readings for the month in seven 5-degree squares varied from 30.04 to 30.11 inches.

The low pressure near St. Johns, Newfoundland, mentioned above, was remarkable for its tenacity, as it existed in that vicinity on 17 days during the month, the barometric readings ranging from 29.26 to 30.06 inches. In the extreme northeast portion of the ocean, the pressure was below the monthly mean on the first two days and from the 11th to the 17th, while it was above on the 9th and 10th and from the 18th to the 26th. In the waters adjacent to the American coast and in the vicinity of the Azores HIGH, the pressure was comparatively uniform, while in mid-ocean, north of the 40th parallel, it was considerably lower in the first two decades of the month than in the last.

GALES.

In the two 5-degree squares between the 40th and 45th parallels and the 35th and 45th meridians, the number of gales during the month was slightly above the normal, while in all other parts of the ocean the conditions were reversed, and along the northern sailing routes, winds of gale force were comparatively rare, as in the 5-degree square where the maximum number was reported they occurred on only three days.

Only two storm tracks for the month are shown on Chart IX (XLIV–63), although there were a number of disturbances reported whose tracks were either too irregular to plot accurately, or the positions of the centers indeterminate on account of lack of observations.

On May 2, a LOW of comparatively limited area was central near latitude 42° N., longitude 44° W., the lowest

barometric reading reported was 29.28 inches, and three vessels encountered winds of from 40 to 60 miles an hour. On the same day a second LOW of slight intensity covered a comparatively large area near Bermuda, while a third depression of slightly greater intensity and less extent than the second was located near latitude 42° N., longitude 25° W. Light to moderate winds circulated around these last two areas, and two vessels reported fog near the 40th parallel, between the 55th meridian and the American coast. From May 3 to 8 low-pressure areas were numerous over a large portion of the ocean, although they were shallow in character and not accompanied by heavy winds. From the 9th to the 11th the pressure over the ocean as a whole was above the normal, and no disturbances were recorded.

On May 12 a LOW (I on Chart IX) of 29.56 inches was located near St. Johns, Newfoundland; moderate winds, and fog prevailed near the center, while from 5 to 7 degrees south of that point winds of from 40 to 55 miles were encountered. This LOW moved in an easterly direction, and on the 13th was central near latitude 48° N., longitude 38° W., westerly and northwesterly gales of from 50 to 60 miles prevailing in the south and southwest quadrants. By the 14th this disturbance, which had remained practically stationary since the preceding day, had increased largely in extent, and a number of vessels a short distance to the south and southwest of the center reported gales of somewhat less force than on the day before. The storm then moved toward the northeast, and on the 15th the wind had moderated considerably, although the barometer had remained practically stationary. The disturbance then increased its rate of translation eastward, and on the 16th was near latitude 50° N., longitude 18° W.; the barometric readings were somewhat lower than on the 15th, although the winds were still moderate in force. It continued in its easterly course, and on May 17 the center was about 5 degrees west of the Scilly Islands, and while the winds near the center were from light to moderate, two vessels in the southwest quadrant reported gales of from 40 to 55 miles.

On May 18 a LOW (II on Chart IX) of 29.35 inches appeared near latitude 51° N., longitude 33° W. There were too few observations in the northern part of the area to determine the conditions accurately, although to the south and southwest of the center, winds of gale force extended to the 43d parallel and the 42d meridian. The LOW moved in an easterly direction and on the 19th, was located near latitude 51° N., longitude 26° W., where the barometer had fallen to 29.21 inches; the storm area had contracted somewhat since the 18th, and winds of gale force still prevailed in the southwest quadrant. The disturbance then curved toward the northeast and on the 20th was central near latitude 53° N., longitude 19° W. The barometer had risen somewhat since the 19th and the wind decreased in force; three vessels a short distance south of the center reported gales of from 40 to 48 miles, however. Between the 21st and 25th there were no disturbances of any importance reported, and the pressure was above the normal over nearly all the North Atlantic.

On May 26 a LOW of 29.66 inches appeared near latitude 40° N., longitude 49° W.; it was of limited extent and accompanied by light to moderate winds. By the 27th this "first" LOW had moved eastward to near latitude 42° N., longitude 43° W., the pressure and wind velocities having remained practically constant since the day before. On May 27 a second LOW of 29.28 inches developed in the Gulf of St. Lawrence and moderate gales were reported by three vessels south of the center, near the 40th parallel. By the 28th the "first" LOW had disappeared and the "second" remained stationary in position and changed but little in intensity, while in the east and southeast quadrants light to moderate winds with fog prevailed. On the 29th this "second" depression was still in the same locality, although the barometric readings were somewhat higher than on the previous day and the winds were of less force.

On the 30th, the "second" LOW had moved a short distance toward the northeast and was central near latitude 50° N., longitude 54° W., while the barometer had fallen to 29.36 inches, without causing any appreciable increase in the velocity of the wind. The disturbance then moved in an easterly course and on the 31st was near latitude 50° N., longitude 43° W.; the pressure had risen to 29.45 inches and winds of gale force were reported from a small area east of the center.

TEMPERATURE.

North of the 45th parallel the average temperature for the month was slightly above the normal, except in the two 5-degree squares between the 50th and 55th parallels and the 10th and 20th meridians, where there was a negative departure of 1°. South of the 50th parallel and between the 40th meridian and the European coast the departures ranged between 0 and +4 degrees, while between the 40th and 70th meridians they varied from +3 to −3 degrees. In the waters adjacent to the American coast they were for the most part negative north of the 35th parallel, and positive south of that line, while in the Gulf of Mexico the temperatures were nearly normal.

The temperature departures for May, 1915, at a number of Canadian and United States Weather Bureau stations on the Atlantic and Gulf coasts were as follows:

St. Johns, N. F., −2.7°; Sydney, C. B. I., −0.8°; Halifax, N. S., −0.4°; Eastport, −0.3°; Portland, −1.3°; Nantucket, −0.4°; New York, −1.6°; Washington, −1.7°; Norfolk, −0.2°; Hatteras, +1.2°; Charleston, +3.1°; Key West, +1.1°; Pensacola, +1.0°; New Orleans, +2.9°; Galveston, +0.1°; Corpus Christi, −0.5°.

The lowest temperature reported during the month was 33° and occurred off the coast of Labrador on the 3d and again on the 20th. The highest temperature was 83°F. and was recorded on a number of days in the Caribbean Sea.

FOG.

During the period from 1901 to 1906, for the month of May, the average percentage of days with fog off the Banks of Newfoundland was from 40 to 45, while in the same region for May, 1915, it was observed on 10 days, a percentage of 32. In the waters adjacent to the American coast, north of the 35th parallel, the percentage ranged from 10 to 19, which was slightly below the normal. Over the central portion of the trans-Atlantic steamer routes no fog was reported, while over the eastern part the percentage ranged from 3 to 10.

PRECIPITATION.

Hail was reported on May 7, near latitude 62, longitude 12, and snow on the 25th, near latitude 47, longitude 50.

Maximum wind velocities, May, 1916.

[Velocities below 50 mis./hour (22.4 m./sec.) are not included here.]

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mis./hr.				*Mis./hr.*	
Abilene, Tex	26	52	s.	Green Bay, Wis	8	54	w.
Alpena, Mich	11	52	w.	Do	10	53	w.
Bismarck, N. Dak.	9	54	nw.	Helena, Mont	6	50	sw.
Buffalo, N. Y	1	56	w.	Houghton, Mich	8	57	sw.
Do	10	72	sw.	Do	10	60	w.
Do	11	61	w.	Do	11	54	sw.
Canton, N. Y	11	56	nw.	Louisville, Ky	27	50	w.
Charlotte, N. C	18	58	nw.	Marquette, Mich	8	60	w.
Cheyenne, Wyo	7	66	w.	Do	10	57	w.
Do	10	62	nw.	Do	11	50	w.
Do	22	58	w.	Memphis, Tenn	30	72	nw.
Columbus, Ohio	17	52	nw.	Modena, Utah	23	59	s.
Devils Lake, N. Dak	7	56	w.	Do	24	58	sw.
Do	10	52	w.	Mobile, Ala	18	55	se.
Duluth, Minn	8	64	w.	Mount Tamalpais, Cal	5	70	sw.
Erie, Pa	10	60	sw.	Do	6	56	nw.
Do	11	52	sw.	Do	7	61	nw.
Evansville, Ind	27	54	sw.	Do	9	72	nw.
Flagstaff, Ariz	24	51	sw.	Do	16	56	nw.
Galveston, Tex	18	59	n.	Do	18	50	nw.
				Do	21	80	nw.
Grand Forks, N. Dak	10	65	w.	Do	22	80	nw.

Maximum wind velocities, May, 1916—Continued.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mis./hr.				*Mis./hr.*	
Mount Tamalpais, Cal	23	80	nw.	Point Reyes Light, Cal	24	59	nw.
Do	24	72	nw.	Do	29	64	nw.
Do	30	71	nw.	Do	30	68	nw.
Do	31	68	nw.	Do	31	50	nw.
North Head, Wash	5	58	s.	Pocatello, Idaho	6	58	sw.
Do	7	74	se.	Port Huron, Mich	11	50	w.
New York, N. Y	9	58	nw.	Providence, R. I	9	50	nw.
Do	12	63	nw.	Rapid City, S. Dak.	7	50	n.
Do	17	52	nw.	Reno, Nev	6	52	sw.
Do	25	54	w.	Saginaw, Mich	10	50	se.
Pierre, S. Dak	9	54	nw.	St. Louis, Mo	27	50	sw.
Do	10	55	nw.	St. Paul, Minn	7	52	nw.
				Do	8	56	nw.
Point Reyes Light, Cal	9	72	nw.	Do	10	50	w.
Do	10	73	nw.	Do	31	62	se.
Do	11	62	nw.	Sand Key, Fla	28	52	nw.
Do	12	50	nw.	Sault Ste. Marie, Mich	8	52	nw.
Do	16	53	nw.	Do	11	53	w.
Do	18	61	nw.	Sheridan, Wyo	9	50	nw.
Do	19	73	nw.				
Do	20	62	nw.	Tatoosh Island, Wash	6	52	s.
Do	21	80	nw.	Do	7	50	s.
Do	22	78	nw.	Toledo, Ohio	10	63	sw.
Do	23	68	nw.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, May, 1916.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		Ins.	Ins.		Ins.		Ins.
Alabama	73.6	+2.2	Tuskegee	102	28	Valley Head	40	5†	4.29	+0.17	Maple Grove	7.09	Camp Hill	1.29
Arizona	64.9	−0.7	2 stations	106	5†	Flagstaff	19	26	0.20	−0.08	Kingman	1.52	32 stations	0.00
Arkansas	71.6	+2.5	Bee Branch	99	28	Pond	34	16	3.56	−1.74	Mena	7.76	Dodd City	1.02
California	58.1	−4.0	Calexico	105	9	Tamarack	8	24	0.61	−0.61	Crescent City	4.88	30 stations	0.00
Colorado	50.9	−0.8	Las Animas	99	8	Longs Peak	1	1	1.34	−0.43	Grover	3.95	Blanca	0.00
Florida	76.5	+0.7	Live Oak	102	10	Middleburg	41	1	3.89	−0.11	Fellsmere	7.55	Panama City	0.44
Georgia	74.3	+2.2	2 stations	103	10†	Blue Ridge	38	5	2.79	−0.40	Fort Gaines	6.28	Concord	1.19
Hawaii (April)	71.4	......	2 stations	89	16†	Waimea, Hawaii	46	29	7.26	......	Olaa (17 miles), Hawaii.	30.56	Kealia, Kauai	0.70
Idaho	48.1	−4.4	Guffey	89	5	Imus Bros. Ranch	3	11	1.58	−0.45	Burke	4.21	Geneva	0.30
Illinois	63.6	+1.0	Sparta	95	10	2 stations	29	2	4.69	+0.51	Quincy	8.92	New Burnside	2.12
Indiana	63.5	+1.3	2 stations	98	25	Salamonia	29	20	4.47	+0.42	Collegeville	8.35	Dam No. 39	2.20
Iowa	59.9	−0.6	2 stations	94	6†	Estherville	27	2	4.93	+0.36	Burlington	10.44	Denison	2.14
Kansas	64.2	+0.4	2 stations	102	7†	Blakeman	24	3	3.69	−0.42	Marion	8.45	Coolidge	0.00
Kentucky	67.2	+1.5	Frankfort	98	28	Maysville	33	19	4.02	+0.10	Franklin	7.15	Manchester	2.07
Louisiana	75.4	+1.1	Angola	107	28	2 stations	42	17	8.17	+3.87	St. Gabriel	13.08	Lakeside	4.08
Maryland-Delaware	64.7	+1.6	Cumberland, Md	101	15	Cumberland, Md	27	19	3.73	+0.26	Princess Anne, Md	6.89	Western Port, Md	1.62
Michigan	53.7	−0.1	Allegan	92	26	Sidnaw	18	1	4.24	+0.92	Wasepi	7.66	Ewen	1.47
Minnesota	53.5	−1.0	Canby	94	7	Littlefork	15	1	4.28	+0.88	Maple Plain	7.08	Warren	1.68
Mississippi	73.2	+1.3	3 stations	98	27†	Macon	41	1	7.44	+3.13	Woodville	12.80	Crenshaw	2.78
Missouri	65.6	+0.7	Grant City (3)	96	6†	Unionville	33	18	5.61	+0.89	Palmyra	10.58	Hollister	2.00
Montana	46.9	−4.2	Melstone	92	6	Clear Creek	10	7	2.24	−0.28	Adel	7.23	Libby	0.55
Nebraska	58.6	−0.6	Imperial	102	6	Fort Robinson	14	11	3.51	−0.08	Pawnee City	9.63	Haigler	1.45
Nevada	52.2	−2.7	Logan	101	8	2 stations	11	9†	0.48	−0.51	Eureka	2.09	2 stations	0.00
New England	54.8	−0.4	Torrington, Conn	89	25	2 stations (Vt.)	24	10	3.85	+0.47	Farmington, Me	6.79	Houlton, Me	1.09
New Jersey	61.1	+0.9	3 stations	90	28	Culvers Lake	32	19	3.48	−0.43	Bergen Point	5.27	Clayton	2.14
New Mexico	59.7	0.0	Tucumcari R.R.Sta.	108	9	Senorito (near)	13	16	0.43	−0.58	Rio Grande Dam	2.00	12 stations	0.00
New York	56.0	−0.2	3 stations	88	15	Gabriels	23	10	4.36	+0.88	York	8.07	Chazy	2.21
North Carolina	69.9	+2.8	Monroe	102	27	2 stations	35	10†	4.67	+0.77	Lillington	9.16	Hatteras	1.98
North Dakota	50.9	−2.2	Forman	95	7	New England	15	2	2.19	−0.38	Forman	5.16	McKinney	0.45
Ohio	61.8	+0.9	New Bremen	95	27	3 stations	29	19†	4.27	+0.62	Akron	8.35	Cleveland	2.04
Oklahoma	70.1	+2.7	Goodwell	104	25	Kenton	28	3	2.13	−3.52	McAlester	6.61	Reno Junction	T.
Oregon	50.5	−3.5	Vale	94	28	Beckley (2)	8	13	2.45	+0.27	Government Camp	8.16	Umatilla	0.20
Pennsylvania	61.0	+1.1	Phoenixville	93	28	West Bingham	26	21	3.19	−0.34	Johnstown	6.09	Catawissa	1.49
Porto Rico	78.3	+1.1	Canovanas	97	25	Albonito	56	13†	8.27	+0.91	Inabon Falls	26.50	Hacienda Potala	2.77
South Carolina	73.8	+2.2	St. Mathews	103	8†	4 stations	42	1	2.44	−1.03	Mountain Rest	7.36	Camden	0.57
South Dakota	54.5	−1.1	3 stations	99	7†	2 stations	16	1	4.18	+1.22	Hardingrove	8.05	Hardy Ranger Sta	1.44
Tennessee	69.6	+2.4	Arlington	98	27	2 stations	34	10†	5.09	+1.09	Springville	9.22	Bluff City	2.38
Texas	74.4	+0.7	Quanah	111	29	2 stations	31	1†	3.80	+0.29	Rockland	13.87	4 stations	0.00
Utah	51.5	−3.4	Kanab	101	8	Pineview	10	10	0.50	−0.99	Pasadena Ranch	1.45	10 stations	0.00
Virginia	66.6	+2.0	Six stations	96	11†	Burkes Garden	25	19	3.92	+0.10	Williamsburg	8.31	Wytheville	1.45
Washington	51.9	−3.1	2 stations	88	15†	Snyders Ranch	22	12	1.80	−0.24	Yale	6.77	4 stations	T.
West Virginia	64.0	+2.2	Moorefield	97	28	Marlinton	28	19	3.55	−0.28	Nuttallburg	6.00	Bluefield	0.90
Wisconsin	54.2	−0.6	Beloit	90	26	Long Lake	20	12	3.85	−0.16	Osceola	7.11	Lancaster	1.41
Wyoming	44.7	−2.8	Lusk	92	30	Fox Park	0	5	1.82	−0.51	Crow Hill	4.81	Opal	T.

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the successive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The Roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0–t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year*.

TABLE I.—*Climatological data for Weather Bureau stations, May, 1916.*

District and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea-level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max. + mean min. ÷ 2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England.							54.4	− 0.1										74	3.69	+ 0.3										6.3		
Eastport	76	67	85	29.78	29.86	−0.10	47.6	+ 0.7	74	11	52	34	1	40	35	43	39	79	1.38	− 2.4	16	7,298	s.	48	e.	17	2	14	15	7.4	......	......
Greenville	1,070	6	......	28.70	29.86	......	49.9	......	79	29	61	26	2	39	39	......	......	......	4.59	......	15	......	......	......	......	......	......	......	......	......	......	......
Portland, Me.	103	82	117	29.78	29.90	− .07	52.4	− 1.1	76	11	60	38	19	44	30	47	41	71	5.64	+ 2.0	12	7,363	s.	40	e.	17	5	16	10	6.3	T.	......
Concord	288	70	79	29.58	29.89	− .09	55.4	− 0.3	84	29	66	35	1	45	38	......	......	......	3.95	+ 0.7	11	4,407	nw.	39	w.	11	10	13	8	5.3	......	......
Burlington	404	11	48	29.44	29.88	− .09	53.9	0.0	80	29	63	30	10	45	30	......	......	......	4.69	+ 1.9	14	8,261	s.	43	s.	11	1	15	15	6.9	......	......
Northfield	876	12	60	28.95	29.90	− .07	51.4	− 2.1	79	29	62	27	10	40	35	47	42	67	3.83	+ 1.0	11	6,071	s.	39	sw.	11	4	9	18	7.1	......	......
Boston	125	115	188	29.76	29.89	− .09	58.6	+ 2.0	85	25	67	44	1	50	28	52	47	71	2.83	− 0.7	11	7,743	sw.	38	w.	12	8	13	10	5.4	......	......
Nantucket	12	14	90	29.90	29.91	− .08	52.0	− 1.0	70	29	58	40	7	46	21	48	46	84	4.35	+ 1.7	14	10,798	sw.	47	se.	17	7	12	12	6.2	......	......
Block Island	26	11	46	29.87	29.90	− .09	52.9	0.0	71	11	59	41	1	47	24	49	47	87	3.20	− 0.6	14	11,279	se.	48	w.	17	8	9	14	6.2	......	......
Narragansett	......	9	......	......	......	......	54.3	− 0.4	80	11	63	37	1	46	34	......	......	......	3.49	......	13	......	sw.	......	......	......	14	8	9	......	......	......
Providence	160	215	251	29.72	29.90	− .08	57.0	− 1.5	83	25	66	40	10	48	29	50	45	69	3.85	+ 0.4	14	9,809	s.	50	nw.	9	6	16	9	5.8	......	......
Hartford	159	122	140	29.73	29.90	− .08	58.8	+ 1.3	84	25	68	41	19	50	28	52	46	69	3.14	− 0.4	13	6,007	s.	31	nw.	17	6	12	13	6.6	......	......
New Haven	106	117	155	29.79	29.90	− .09	58.5	+ 0.9	82	25	67	42	1	50	29	52	47	71	3.69	0.0	12	6,550	nw.	29	w.	11	9	10	12	6.3	......	......
Middle Atlantic States.							63.6	+ 8.0										65	3.40	− 0.1										5.4		
Albany	97	102	115	29.79	29.89	− .09	58.2	− 0.7	85	29	68	41	10	49	30	51	45	64	2.71	− 0.3	13	6,472	s.	30	nw.	8	11	11	9	5.1	......	......
Binghamton	871	10	69	28.99	29.92	− .06	58.0	+ 1.0	82	28	68	39	21	48	32	......	......	......	4.29	+ 1.2	16	2,243	nw.	16	nw.	3	5	15	11	6.2	......	......
New York	314	414	454	29.58	29.91	− .08	59.8	+ 0.5	77	29	67	44	18	52	23	52	45	63	3.49	+ 0.3	14	12,289	nw.	63	nw.	12	4	13	14	6.6	......	......
Harrisburg	374	94	104	29.54	29.94	− .04	63.4	+ 1.7	87	28	72	41	19	55	31	54	46	59	2.25	− 1.4	12	5,385	nw.	31	nw.	28	6	14	11	6.0	......	......
Philadelphia	117	123	190	29.81	29.94	− .05	64.7	+ 2.5	86	28	73	45	19	56	25	56	49	63	2.75	− 0.4	11	7,737	nw.	37	n.	25	8	12	11	5.8	......	......
Reading	325	81	98	29.59	29.94	......	63.2	......	87	28	72	42	19	54	30	54	46	60	2.82	− 0.6	12	5,555	se.	30	n.	30	5	10	16	6.5	......	......
Scranton	805	111	119	29.07	29.92	− .06	60.4	+ 1.6	85	28	70	40	19	50	36	52	46	62	3.04	− 0.4	16	5,679	sw.	34	sw.	22	7	11	13	6.2	......	......
Atlantic City	52	37	48	29.89	29.94	− .04	60.3	+ 2.8	81	11	67	45	19	53	31	54	49	73	3.91	+ 0.9	11	5,824	sw.	26	w.	28	9	7	15	6.2	......	......
Cape May	18	13	49	29.95	29.97	− .02	60.8	+ 2.2	82	2	68	47	10	54	28	......	......	......	4.02	+ 1.0	12	6,144	s.	36	nw.	17	11	16	4	4.9	......	......
Sandy Hook	22	10	57	29.90	29.92	......	58.8	......	79	30	66	44	1	52	22	53	50	79	3.57	......	15	10,086	nw.	41	nw.	12	9	11	11	5.7	......	......
Trenton	190	159	183	29.71	29.91		62.2	......	87	28	71	42	19	53	34	55	49	69	2.45	− 1.1	10	8,580	w.	42	w.	17	8	9	14	6.2	......	......
Baltimore	123	100	113	29.81	29.94	− .05	66.6	+ 2.4	92	28	75	47	19	59	29	58	52	63	3.49	− 0.1	11	5,673	sw.	40	nw.	28	10	11	10	5.6	......	......
Washington	112	62	85	29.81	29.93	− .07	66.7	+ 2.5	93	28	77	46	10	57	33	58	52	68	2.30	− 1.5	11	4,929	nw.	32	nw.	28	10	11	10	5.6	......	......
Lynchburg	681	153	188	29.21	29.94	− .06	69.0	+ 3.1	93	28	80	47	1	57	38	58	51	59	5.13	+ 1.1	9	5,501	w.	36	nw.	28	10	16	5	4.7	......	......
Norfolk	91	170	205	29.86	29.96	− .04	69.2	+ 3.0	91	28	78	51	18	60	28	61	57	70	5.48	+ 1.4	14	10,053	sw.	43	w.	7	15	12	4	3.8	......	......
Richmond	144	11	52	29.80	29.94	− .05	69.7	+ 2.4	93	28	81	47	19	59	34	61	55	66	4.74	+ 0.9	12	6,073	sw.	38	nw.	28	15	10	6	4.6	......	......
Wytheville	2,293	49	55	27.63	29.95	− .04	63.7	+ 2.3	87	28	76	38	19	52	40	56	51	66	1.45	− 2.5	6	4,884	w.	32	nw.	17	21	7	3	2.7	......	......
South Atlantic States.							72.8	+ 3.0										68	2.48	− 1.3										4.2		
Asheville	2,255	70	84	27.66	29.96	− .03	65.6	+ 3.0	88	28	77	44	19	54	34	56	50	63	3.60	− 0.2	9	5,881	nw.	33	s.	3	12	13	6	4.5	......	......
Charlotte	773	153	161	29.14	29.96	− .03	72.6	+ 3.2	96	27	83	53	1	62	29	61	54	60	4.41	+ 0.5	10	8,105	sw.	58	nw.	18	15	12	4	3.8	......	......
Hatteras	11	12	50	29.97	29.98	− .03	69.4	+ 2.3	82	2	75	49	1	64	23	64	62	80	1.98	− 2.2	10	10,199	sw.	38	nw.	17	10	14	7	4.8	......	......
Manteo	12	4	46	......	......	......	68.6	......	90	11	69	41	1	40	......	......	......	......	2.65	− 1.4	9	......	sw.	......	......	......	15	8	8	......	......	......
Raleigh	376	103	110	29.57	29.96	− .03	71.7	+ 3.6	96	27	82	52	1	62	30	62	55	62	2.95	− 1.9	11	6,314	sw.	34	nw.	27	11	13	7	5.0	......	......
Wilmington	78	81	91	29.90	29.98	− .03	71.8	+ 3.7	92	26	80	51	1	64	28	65	62	76	3.35	− 0.7	8	6,313	sw.	27	e.	12	17	7	7	3.9	......	......
Charleston	48	11	92	29.92	29.98	− .03	74.4	+ 2.0	90	7	82	56	1	67	24	67	63	72	1.22	− 2.2	3	8,175	s.	35	ne.	14	17	8	6	3.5	......	......
Columbia, S. C.	351	41	57	29.59	29.96	− .04	75.9	+ 4.1	99	27	87	56	19	64	34	63	56	59	0.58	− 2.6	7	5,887	sw.	33	sw.	18	17	8	6	4.0	......	......
Augusta	180	62	77	29.76	29.95	− .04	75.6	+ 3.4	99	27	87	53	1	64	36	65	59	61	1.65	− 1.6	4	4,626	se.	23	se.	22	16	10	5	3.5	......	......
Savannah	65	150	194	29.91	29.98	− .02	75.4	+ 2.9	95	8	84	58	1	67	27	66	63	72	1.61	− 1.4	5	9,137	s.	36	w.	23	14	10	7	4.3	......	......
Jacksonville	43	200	245	29.93	29.98	− .02	75.6	+ 1.4	94	9	84	60	1	67	26	67	63	72	3.32	− 0.9	9	8,939	ne.	45	ne.	14	14	8	9	4.4	......	......
Florida Peninsula.							77.0	− 0.2										76	3.46	− 0.8										5.1		
Key West	22	10	64	29.93	29.95	− .02	78.9	− 0.1	88	20	84	68	28	74	15	72	70	76	2.69	− 0.7	5	6,964	se.	38	w.	28	14	10	7	4.3	......	......
Miami	25	71	79	29.93	29.96	......	76.7	− 1.9	90	24	82	65	9	71	17	71	68	75	5.99	− 0.4	11	6,890	e.	25	e.	12	4	18	9	6.2	......	......
Sand Key	23	39	72	29.90	29.93	− .04	77.4	......	85	31	80	66	28	75	13	73	71	82	4.11	......	7	8,525	e.	52	nw.	28	15	11	5	3.9	......	......
Tampa	35	79	96	29.93	29.96	− .03	76.7	+ 1.2	91	10	85	57	1	69	24	68	64	70	1.71	− 1.2	7	5,480	ne.	26	ne.	14	9	13	9	5.4	......	......
Titusville	44	6	......	29.90	29.95	......	75.8	− 0.1	92	31	84	55	18	68	27	......	......	......	4.23	......	13	......	se.	......	......	......	8	10	13	5.9	......	......
East Gulf States.							74.5	+ 2.2										67	5.04	+ 1.5										3.6		
Atlanta	1,174	190	216	29.76	29.97	− .02	72.6	+ 3.1	95	27	83	50	5	63	28	61	54	57	3.57	+ 0.5	7	7,827	nw.	30	nw.	17	19	7	5	3.8	......	......
Macon	370	78	87	29.56	29.95	− .04	75.0	+ 3.9	98	11	87	54	6	63	36	64	57	58	1.71	− 1.2	4	4,273	nw.	24	nw.	30	19	8	4	3.4	......	......
Thomasville	273	49	58	29.67	29.96	− .03	76.4	+ 2.4	98	27	88	57	5	65	32	65	59	62	1.54	− 2.5	8	3,844	ne.	20	s.	22	15	7	9	4.5	......	......
Pensacola	56	140	182	29.90	29.96	− .03	75.3	+ 0.5	92	27	82	59	19	69	20	68	65	75	5.42	+ 2.7	5	9,202	se.	43	e.	18	16	11	4	3.7	......	......
Anniston	741	9	57	29.21	29.99	.00	71.2	+ 2.8	95	27	84	43	5	58	41	......	......	......	4.28	+ 1.2	8	3,355	nw.	22	nw.	30	21	6	4	2.8	......	......
Birmingham	700	11	48	29.23	29.98	.00	72.7	+ 1.1	94	28	84	48	5	62	32	63	58	66	5.85	+ 2.8	10	4,356	s.	44	se.	3	18	8	5	3.8	......	......
Mobile	57	125	161	29.90	29.96	− .03	76.4	+ 2.8	96	27	85	59	19	68	24	68	65	73	6.08	+ 2.1	6	6,661	sw.	55	se.	18	18	10	3	3.5	......	......
Montgomery	223	100	112	29.73	29.97	− .02	75.4	+ 1.9	99	27	86	52	5	64	32	65	59	61	2.99	− 0.8	7	4,279	w.	35	nw.	16	19	8	4	3.0	......	......
Corinth	469	6	......	......	......	......	71.8	......	94	28	84	46	17	60	36	......	......	......	5.68	......	9	......	s.	......	......	......	15	7	9	......	......	......
Jackson	304	5	......	......	......	......	74.2	......	95	28	86	49	5	62	34	......	......	......	7.42	......	9	......	s.	......	......	......	13	15	3	......	......	......
Meridian	375	85	93	29.56	29.95	− .03	73.2	+ 2.1	95	27	84	50	5	62	31	66	62	71	7.93	+ 4.0	9	3,041	sw.	27	se.	21	20	4	7	3.9	......	......
Vicksburg	247	65	74	29.68	29.96	− .01	74.2	+ 1.3	94	28	83	54	4	65	25	67	64	75	8.09	+ 3.8	8	4,510	sw.	26	se.	2	17	8	6	4.2	......	......
New Orleans	51	76	84	29.90	29.95	− .02	77.1	+ 2.6	95	27	85	56	18	69	22	70	66	74	7.97	+ 4.1	7	4,800	se.	35	se.	18	20	6	5	3.5	......	......
West Gulf States.							73.4	+ 0.5										73	4.27	+ 0.6										4.5		
Shreveport	249	77	93	29.65	29.92	− .03	73.8	+ 0.6	91	27	83	53	4	64	28	66	63	73	5.01	+ 0.8	6	5,444	s.	36	s.	21	18	9	4	3.7	......	......
Bentonville	1,303	11	44	28.53	29.88	− .05	67.0	+ 0.6	87	24	77	42	16	56	33	......	......	......	2.65	− 2.6	12	4,871	s.	23	s.	14	10	11	10	5.0	......	......
Fort Smith	457	79	94	29.40	29.87	− .06	72.2	+ 2.5	91	26	82	46	4	62	33	64	60	68	3.29	− 1.6	7	6,432	e.	40	nw.	20	11	14	6	4.6	......	......
Little Rock	357	139	147	29.54	29.91	− .04	72.2	+ 1.8	92	27	82	49	4	62	30	63	58	65	1.49	− 3.6	5	7,412	s.	46	sw.	29	19	7	5	3.5	......	......
Brownsville	57	3	40	......	......	......	80.3	......	102	22	88	63	4	72	27	......	......	......	0.37	......	6	......	se.	......	......	......	......	......	......	......	......	......
Corpus Christi	20	69	77	29.86	29.88	− .02	76.5	0.0	88	22	81	62	3	72	18	72	70	83	0.60	− 2.2	5	12,940	se.	46	se.	20	3	19	9	6.0	......	......
Dallas	512	109	117	29.34	29.88	......	72.6	......	95	29	82	48	15	63	25	......	......	......	3.63	......	7	8,852	se.	40	n.	15	13	9	9	4.9	......	......
Fort Worth	670	106	114	29.15	29.86	− .05	72.8	− 0.4	99	29	83	49	3	63	29	63	58	68	3.70	− 0.4	5	9,469	s.	34	s.	14	13	9	9	4.9	......	......
Galveston	54	106	114	29.87	29.94	.00	75.0	− 0.4	84	30	79	58	18	71	17	70	69	84	8.08	+ 4.8	5	9,641	s.	59	n.	18	20	5	6	3.8	......	......
Houston	138	111	121	29.77	29.91	......	75.4	− 0.1	93	30	85	57	18	66	26	......	......	......	4.40	......	8	6,982	se.	30	ne.	18	8	13	10	5.8	......	......
Palestine	510	64	72	29.37	29.90	− .03	73.0	+ 0.5	93	30	82	54	3	64	24	66	63	78	8.00	+ 3.1	8	6,162	s.	28	s.	21	20	3	8	3.9	......	......
San Antonio	701	109	132	29.14	29.85	− .05	76.1	+ 1.3	98	31	87	52	2	65	32	66	61	68	3.85	+ 0.9	5	7,387	sw.	33	ne.	18	15	12	4	3.9	......	......
Taylor	582	55	63	29.30	29.91	.00	73.6	− 0.7	95	30	84	50	4	64	30	......	......	......	6.06	+ 2.0	6	8,346	s.	31	s.	10	12	15	4	4.5	......	......

TABLE I.—*Climatological data for Weather Bureau stations, May, 1916*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea-level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max. + mean min. ÷ 2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0–10	In.	In.
Ohio Valley and Tennessee.							**66.7**	**+ 1.5**										**65**	**3.93**	**+ 0.2**										**5.4**		
Chattanooga	762	189	213	29.18	29.98	-0.01	71.5	+ 2.9	92	27	82	47	5	61	37	61	55	61	3.45	- 0.2	7	5,606	w.	33	s.	1	13	11	7	4.4		
Knoxville	996	93	100	28.92	29.96	- .03	69.8	+ 3.3	92	27	82	47	5	58	42	60	53	59	4.71	+ 1.0	9	3,463	sw.	28	n.	15	11	9	11	5.3		
Memphis	399	76	97	29.54	29.96	.00	73.0	+ 2.3	95	13	82	49	4	64	29	64	60	68	4.09	- 0.2	8	6,289	sw.	72	nw.	30	17	6	8	3.6		
Nashville	546	168	191	29.39	29.97	- .01	70.5	+ 1.7	91	27	81	48	5	60	34	62	56	63	5.37	+ 1.9	10	6,344	s.	39	nw.	15	13	12	6	4.4		
Lexington	989	193	230	28.91	29.96	- .03	67.0	+ 2.7	89	26	76	44	17	58	30				2.92	- 0.6	8	9,850	sw.	48	sw.	1	13	11	7	4.6		
Louisville	525	219	255	29.38	29.96	- .02	68.0	+ 1.3	90	26	78	47	19	59	30	59	52	61	3.39	- 0.2	9	9,109	s.	50	w.	27	10	11	10	5.5		
Evansville	431	139	175	29.47	29.93	- .04	68.6	+ 1.5	90	25	78	47	2	59	29	60	55	66	3.72	+ 0.3	13	8,517	s.	54	sw.	27	6	16	9	5.8		
Indianapolis	822	194	230	29.06	29.94	- .03	63.4	+ 0.1	89	26	72	43	2	54	30	55	50	65	3.54	- 0.4	18	9,544	sw.	42	sw.	15	6	13	12	6.2		
Terre Haute	575	96	129	29.30	29.92		65.4		92	25	75	44	18	56	30	57	52	67	3.29		15	8,011	sw.	35	sw.	10	1	23	7	6.5		
Cincinnati	628	11	51	29.27	29.94	- .05	64.5	+ 1.4	89	14	74	39	19	55	32	57	51	64	4.49	+ 1.0	16	5,666	sw.	36	sw.	27	10	12	9	5.8		
Columbus	824	173	222	29.08	29.94	- .04	62.6	+ 0.3	87	26	72	41	19	53	32	57	52	72	4.81	+ 1.1	16	8,542	sw.	52	nw.	17	17	7	7	4.3		
Dayton	899	181	216	28.97	29.91		62.8	- 0.1	88	26	72	42	19	54	30	56	51	68	3.21	- 0.7	17	7,346	sw.	42	nw.	6	7	13	11	6.3		
Pittsburgh	842	353	410	29.04	29.94	- .05	63.2	+ 0.6	85	15	72	42	19	54	31	54	47	61	2.33	- 1.0	11	8,400	nw.	46	nw.	27	3	14	14	6.8		
Elkins	1,940	41	50	27.94	29.95	- .05	62.4	+ 0.3	87	14	75	34	19	50	43	54	48	67	4.29	+ 0.3	18	3,426	w.	26	w.	17	4	10	17	7.0		
Parkersburg	638	77	84	29.31	29.97	- .02	65.9	+ 2.6	91	26	76	38	19	56	37	57	52	68	4.65	+ 1.2	15	4,304	nw.	32	nw.	17	12	10	9	5.2		
Lower Lake Region.							**57.0**	**- 0.5**										**71**	**4.14**	**+ 1.0**										**5.9**		
Buffalo	767	247	280	29.08	29.91	- .06	52.8	- 1.7	78	29	61	36	3	45	30	49	46	80	4.13	+ 1.0	17	12,985	sw.	72	sw.	10	5	15	11	6.0		
Canton	448	10	61	29.40	29.87		53.9	- 2.3	77	24	63	34	3	45	30				4.59	+ 1.7	15	8,597	w.	56	w.	11	11	10	10	5.4		
Oswego	335	76	91	29.53	29.90	- .07	54.0	- 0.7	79	1	63	37	3	45	28	48	44	75	4.60	+ 1.8	18	7,530	w.	31	sw.	10	11	7	13	5.4		
Rochester	523	97	113	29.35	29.92	- .05	57.1	+ 0.4	80	24	66	38	2	48	35	50	44	66	5.80	+ 2.9	16	7,128	w.	48	w.	11	7	8	16	6.5		
Syracuse	597	97	113	29.28	29.92	- .06	56.5	- 0.8	79	1	66	38	2	47	31	49	44	67	3.87	+ 0.5	18	9,419	nw.	47	nw.	11	8	10	13	6.0		
Erie	714	130	166	29.15	29.92	- .06	56.8	- 0.5	86	15	65	38	2	48	42	51	47	73	3.85	+ 0.4	15	10,199	sw.	60	sw.	10	6	17	8	5.5		
Cleveland	762	190	201	29.11	29.93	- .05	58.0	- 0.5	82	15	66	37	2	50	34	53	48	70	2.04	- 1.2	11	9,801	w.	48	sw.	10	3	17	11	6.4		
Sandusky	629	62	103	29.24	29.92	- .06	59.2	0.0	82	10	67	41	18	52	31	53	48	69	3.60	+ 0.4	14	9,402	sw.	44	sw.	10	4	15	12	6.5		
Toledo	628	208	243	29.24	29.92	- .05	59.8	+ 0.1	84	24	68	41	3	52	32	54	50	71	3.85	+ 0.6	13	11,205	sw.	63	sw.	10	10	10	11	5.5		
Fort Wayne	856	113	124	29.01	29.93		60.9	+ 0.7	88	26	70	37	2	51	36	55	51	73	3.70		12	7,348	sw.	42	sw.	10	11	5	15	6.0		
Detroit	730	218	245	29.13	29.92	- .05	57.8	- 0.1	80	10	66	39	18	50	28	51	46	69	5.08	+ 1.8	13	7,828	w.	44	w.	11	5	14	12	6.2		
Upper Lake Region.							**52.6**	**- 0.1**										**70**	**3.61**	**+ 0.3**										**6.1**		
Alpena	609	13	92	29.23	29.89	- .08	50.3	+ 0.8	82	23	59	32	2	42	34	45	40	70	3.53	+ 0.2	12	9,256	se.	52	w.	11	10	13	8	5.1		
Escanaba	612	54	60	29.20	29.86	- .11	49.2	- 0.8	78	23	57	32	2	42	31	44	38	69	3.22	- 0.2	15	7,740	s.	44	nw.	8	7	13	11	5.7	T.	
Grand Haven	632	54	92	29.20	29.88	- .06	54.3	- 0.5	85	26	63	30	2	46	28	49	44	73	4.12	+ 0.8	16	8,339	w.	40	sw.	8	10	12	9	5.2		
Grand Rapids	707	70	87	29.13	29.90	- .07	57.8	- 1.2	88	26	68	36	2	48	28	51	45	65	4.13	+ 0.8	12	5,452	w.	30	w.	11	8	12	11	5.9	T.	
Houghton	684	62	72	29.09	29.82	- .15	49.2	- 0.5	74	31	58	30	1	40	37				3.53	+ 0.2	11	9,229	e.	60	w.	10	6	13	12	6.2	T.	
Lansing	878	11	62	28.96	29.90		56.6	- 1.3	83	27	67	35	20	46	30	51	46	72	5.13	+ 1.6	16	5,132	sw.	28	nw.	11	7	9	15	6.2		
Ludington	637	60	66	29.18	29.88		51.6		84	26	59	29	2	44	27	47	43	73	4.18		15	7,916	s.	39	sw.	6	10	13	8	5.3	T.	
Marquette	734	77	111	29.08	29.88	- .09	48.7	- 0.3	77	23	58	32	1	40	33	42	36	63	1.78	- 1.5	12	7,839	se.	60	w.	8	5	9	17	7.3	T.	
Port Huron	638	70	120	29.21	29.90	- .07	53.6	- 0.1	80	24	62	36	2	45	32	49	45	73	4.70	+ 1.5	15	8,250	w.	50	w.	11	6	16	9	5.9		
Saginaw	641	48	82	29.20	29.90		56.4		82	28	66	36	2	47	26	51	45	68	4.37	+ 0.2	15	7,532	sw.	50	se.	10	7	6	18	7.0		
Saulte Sainte Marie	614	11	61	29.20	29.90	- .05	47.1	- 0.6	76	28	56	29	4	38	31	43	37	70	3.17	- 0.1	13	8,129	w.	53	w.	11	9	7	15	6.3	T.	
Chicago	823	140	310	29.02	20.90	- .06	59.3	+ 2.8	90	26	67	40	2	52	32	53	48	70	2.93	- 0.4	12	9,341	w.	39	w.	8	9	11	11	5.8		
Green Bay	617	109	144	29.19	29.84	- .11	54.8	+ 0.3	78	28	63	33	1	46	28	50	46	74	3.94	+ 0.4	17	9,762	s.	54	w.	8	5	12	14	6.9	T.	
Milwaukee	681	119	133	29.14	29.88	- .08	54.9	+ 1.3	87	26	62	35	1	47	34	49	43	67	2.39	- 1.0	13	7,925	sw.	38	sw.	15	10	13	8	5.2		
Duluth	1,133	11	47	28.62	29.84	- .12	47.4	- 1.2	72	5	56	30	1	39	32	42	36	70	3.57	+ 1.0	15	11,994	ne.	64	w.	8	4	13	14	6.9	T.	
North Dakota.							**51.7**	**- 2.6**										**62**	**2.20**	**- 0.3**										**5.3**		
Moorhead	940	8	57	28.82	29.84	- .10	53.0	- 1.8	85	7	64	25	1	42	37	47	41	70	3.76	+ 0.8	12	7,923	nw.	48	nw.	7	19	6	6	3.6		
Bismarck	1,674	8	57	28.08	29.86	- .06	52.8	- 2.4	89	6	65	25	1	40	47	44	35	57	1.95	- 0.6	13	9,590	nw.	54	nw.	9	12	10	9	4.9	T.	
Devils Lake	1,482	11	44	28.24	29.80	- .14	50.3	- 2.4	83	7	62	24	1	39	40	44	35	59	1.47	- 0.7	12	10,711	w.	56	w.	7	4	13	14	6.7		
Grand Forks	835	12	89	28.90	29.81		51.2		84	7	63	25	3	39	38				2.59		10			65	w.	10	14	11	6		T.	
Williston	1,872	41	48	27.85	29.82	- .11	50.6	- 3.7	83	6	62	23	1	39	42	43	35	60	1.61	- 0.6	10	8,235	w.	48	nw.	9	6	14	11	5.9	T.	
Upper Mississippi Valley.							**62.0**	**- 0.1**										**67**	**4.49**	**+ 0.3**										**5.8**		
Minneapolis	918	10	208	28.83	29.80		56.9		83	6	66	34	2	48	31				6.97	+ 3.0	15	10,212	w.	48	w.	7	5	10	16	6.9	T.	
St. Paul	837	201	236	28.91	29.82	- .12	56.6	- 1.6	82	7	66	33	2	47	31				5.89	+ 2.3	18	11,167	nw.	62	se.	31	9	17	5	5.0		
La Crosse	714	11	48	29.07	29.84	- .10	58.8	- 0.7	85	25	69	34	2	49	30				3.17	- 0.6	15	4,729	s.	30	sw.	15	7	10	14	6.2		
Madison	974	70	78	28.84	29.88	- .08	57.3	- 0.3	85	26	66	34	1	48	27	50	44	64	2.38	- 1.2	12	7,626	se.	37	sw.	15	6	10	15	6.7		
Wausau	1,247	4		28.52	29.85		52.8		79	6	63	32	12	42	34				2.64		17		w.				12	8	11	5.5		
Charles City	1,015	10	49	28.77	29.84	- .10	57.9	- 1.6	85	25	69	30	2	47	39	52	47	70	3.97	- 1.0	13	6,587	se.	34	s.	9	6	20	5	5.4		
Davenport	606	71	79	29.22	29.87	- .08	61.3	- 0.2	85	7	70	37	18	52	29	54	49	67	3.52	- 0.7	15	6,394	sw.	31	sw.	26	7	10	14	6.2		
Des Moines	861	84	97	28.94	29.83	- .10	61.7	+ 0.1	86	25	71	35	18	52	34	55	49	65	3.87	- 0.7	12	6,731	s.	36	sw.	10	8	13	10	6.0		
Dubuque	698	81	96	29.14	29.88	- .07	60.0	- 0.8	85	25	69	35	2	51	31	53	47	65	2.49	- 1.8	17	5,529	s.	29	nw.	7	8	8	15	6.3		
Keokuk	614	64	78	29.22	29.88	- .06	62.6	- 0.6	86	25	72	38	18	54	27	57	52	70	6.63	+ 2.4	14	6,279	s.	36	sw.	10	9	16	6	4.6		
Cairo	356	87	93	29.54	29.91	- .05	70.3	+ 2.8	90	26	79	49	2	61	29	61	56	68	3.06	- 0.8	9	6,357	s.	34	n.	11	11	11	9	5.4		
Peoria	609	11	45	29.25	29.91	- .05	61.4	- 0.3	88	26	71	35	2	51	37	56	51	73	7.51	+ 3.2	13	5,461	s.	30	sw.	14	6	16	9	5.9		
Springfield, Ill	644	10	91	29.22	29.90	- .05	64.6	+ 1.1	92	26	74	42	18	55	28	56	51	66	4.21	- 0.3	14	6,666	s.	26	w.	16	6	10	15	6.4		
Hannibal	534	74	109	29.32	29.89	- .05	63.9	- 0.5	89	24	74	43	1	54	35				6.25	+ 1.2	17	7,542	sw.	42	e.	12	10	9	12	5.5		
St. Louis	567	265	303	29.30	29.90	- .05	68.0	+ 1.5	91	25	77	45	3	59	30	58	52	62	3.00	- 1.2	12	10,179	sw.	50	sw.	27	15	9	7	4.4		
Missouri Valley.							**61.7**	**- 0.3**										**65**	**4.18**	**0.0**										**4.8**		
Columbia, Mo.	781	11	84	29.06	29.88	- .06	65.0	+ 0.5	89	24	74	44	4	56	35				5.21	+ 0.4	16	6,336	s.	36	w.	27	11	6	14	5.8		
Kansas City	963	161	181	28.83	29.85	- .07	65.4	+ 0.9	91	24	75	42	3	56	33	57	51	64	5.36	+ 0.2	14	9,538	s.	44	s.	28	13	12	6	4.6		
St. Joseph	967	11	49	28.83	29.85		64.2		91	24	74	40	3	54	32	56	51	68	7.79		13	6,924	se.	33	nw.	7	9	16	6	4.8		
Springfield, Mo.	1,324	98	104	28.51	29.89	- .04	65.8	+ 1.2	87	24	75	42	3	56	30	58	54	69	2.78	- 2.8	11	8,335	s.	34	w.	14	16	13	2	3.5		
Iola	984	11	50	28.81	29.84	- .08	66.0	+ 1.5	91	24	77	40	3	55	35				2.98	- 2.1	11	6,381	s.	36	se.	14	14	11	6	3.8		
Topeka	983	85	101				64.9	- 0.1	92	24	76	40	1	54	38				4.95	+ 0.1	11	8,354	s.	38	s.	10	11	13	7	4.8		
Drexel	1,299	10	53	28.46	29.84		60.4		89	6	72	32	1	49	37	54	48	71	6.22		12	9,756	s.	46	s.	9	13	7	11	5.4		
Lincoln	1,189	11	84	28.57	29.82	- .09	62.2	- 0.7	94	6	74	32	1	50	37	53	47	65	3.48	- 0.8	12	8,641	s.	46	w.	15	13	7	11	5.2		
Omaha	1,105	115	121	28.67	29.83	- .09	63.0	+ 0.5	90	25	73	36	1	53	33	54	47	62	4.57	+ 0.1	11	6,232	nw.	39	nw.	10	13	9	9	4.9		
Valentine	2,598	47	54	27.42	29.84	- .06	55.0	- 2.9	94	9	68	25	1	42	50	47	39	62	3.42	+ 0.1	11	9,136	nw.	40	nw.	10	11	9	11	5.3	T.	
Sioux City	1,135	94	164	28.61	29.81	- .11	60.8	0.0	91	6	72	32	1	49	40	53	46	65	4.58	+ 0.2	11	10,185	nw.	49	nw.	10	17	9	5	3.7		
Huron	1,306	59	74	28.44	29.84	- .08	56.0	- 1.3	94	7	68	23	1	44	46	49	43	66	3.83	+ 0.9	13	9,653	nw.	48	nw.	10	14	9	8	4.8	T.	
Pierre	1,572	70	75	28.17	29.84	- .07	56.9	- 2.4	94	9	69	29	1	45	44	48	38	57	5.81	+ 3.7	14	9,098	nw.	55	nw.	10	11	11	9	5.3	1.0	
Yankton	1,233	49	57	28.50	29.80	- .12	59.6	- 0.4	97	7	71	31	1	48	47				3.35	- 0.6	11	7,259	w.	44	nw.	7	7	15	9	5.9	T.	

TABLE I.—*Climatological data for Weather Bureau stations, May, 1916*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.												Precipitation.			Wind.										
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea-level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity: Miles per hour.	Maximum velocity: Direction.	Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*								0–10	*In.*	*In.*
Northern Slope.							**49.3**	**− 3.7**										**60**	**2.30**	**− 0.1**										**5.5**		
Billings	3,140	5	.....				51.7	.....	91	6	65	24	8	39	.....	.....	.....	.....	2.38	.....	12	.....	sw.	.....	.....	.....	10	13	8	.....	.....	.....
Havre	2,505	11	44	27.24	29.86	−0.04	49.4	− 4.7	85	6	62	27	13	37	42	43	36	67	3.00	+ 0.9	16	7,378	sw.	48	nw.	6	5	17	9	6.0	T.	.....
Helena	4,110	87	114	25.72	29.91	− .02	47.1	− 4.5	82	6	58	29	2	36	43	38	30	59	2.93	+ 1.0	15	7,361	sw.	50	sw.	6	7	15	9	5.6	8.2	.....
Kalispell	2,962	11	34	26.86	29.92	+ .04	47.1	− 3.9	74	6	59	28	12	35	38	40	33	64	1.11	− 0.9	13	4,476	w.	34	sw.	9	3	19	9	6.3	T.	.....
Miles City	2,371	26	48	27.35	29.90	− .01	53.8	− 2.9	88	6	66	30	1	42	49	46	38	62	1.30	− 0.7	10	5,364	w.	36	nw.	9	6	18	7	5.3	T.	.....
Rapid City	3,259	50	58	26.48	29.88	− .02	52.0	− 2.2	88	9	63	30	1	41	43	43	33	52	4.75	+ 1.8	14	7,463	n.	50	n.	7	9	14	8	5.5	0.2	.....
Cheyenne	6,088	84	101	23.89	29.80	− .05	48.6	− 2.4	82	9	61	17	1	36	44	39	29	53	1.93	− 0.5	10	11,311	w.	66	w.	7	13	12	6	4.8	2.9	.....
Lander	5,372	60	68	24.54	29.87	− .01	47.7	− 4.3	82	6	62	19	1	34	47	38	27	57	1.51	− 1.4	10	5,272	w.	44	sw.	25	9	16	6	5.1	3.6	.....
Sheridan	3,790	10	47	26.01	29.90	.....	49.0	.....	85	6	62	27	17	36	53	41	32	62	3.04	.....	15	5,923	nw.	50	nw.	9	10	11	10	5.5	1.0	.....
Yellowstone Park	6,200	11	48	23.78	29.90	− .01	40.0	− 7.4	71	6	51	18	10	29	35	33	26	64	2.23	+ 0.3	14	6,161	s.	49	s.	9	6	10	15	6.4	13.5	.....
North Platte	2,821	11	51	26.95	29.84	− .04	58.2	− 0.8	94	9	72	27	3	45	48	48	40	60	1.95	− 1.1	8	6,720	w.	36	n.	25	18	4	9	4.1	.....	.....
Middle Slope.							**62.8**	**− 0.2**										**58**	**2.33**	**− 1.1**										**4.4**		
Denver	5,292	106	113	24.60	29.80	− .04	55.4	− 1.3	89	9	68	24	1	43	39	43	29	45	1.49	− 1.0	6	6,575	se.	43	se.	23	15	9	7	4.4	0.5	.....
Pueblo	4,685	80	86	25.16	29.77	− .06	59.0	− 0.5	95	9	74	31	16	44	48	45	31	45	0.63	− 1.0	3	5,761	nw.	44	nw.	22	15	12	4	3.6	T.	.....
Concordia	1,392	50	58	28.38	29.83	− .08	63.2	− 0.5	94	6	74	36	1	52	40	55	48	64	3.99	− 0.7	10	7,046	se.	32	s.	9	8	15	8	5.4	.....	.....
Dodge	2,509	11	51	27.26	29.82	− .05	63.6	+ 0.1	99	7	77	32	1	50	45	54	48	65	0.41	− 2.9	8	9,106	s.	37	s.	25	15	10	6	4.2	.....	.....
Wichita	1,358	139	158	28.40	29.80	− .10	66.2	+ 0.3	92	24	76	39	1	56	40	58	52	65	5.11	+ 0.2	9	11,425	s.	46	s.	13	16	9	6	4.4	.....	.....
Altus	1,410	5	.....	.....	.....	.....	71.4	.....	100	7	86	42	3	57	42	.....	.....	.....	1.59	.....	6	.....	se.	.....	.....	.....	20	5	6	.....	.....	.....
Muskogee	652	4	.....	.....	.....	.....	70.4	.....	90	26	81	45	16	60	33	.....	.....	.....	3.54	.....	7	.....	se.	.....	.....	.....	17	4	10	.....	.....	.....
Oklahoma	1,214	10	47	28.58	29.83	− .06	69.1	+ 1.0	91	23	80	40	3	58	32	61	55	67	0.59	− 5.2	5	12,466	s.	43	s.	13	12	15	4	4.4	.....	.....
Southern Slope.							**71.4**	**+ 0.8**										**49**	**1.54**	**− 1.2**										**3.1**		
Abilene	1,738	10	52	28.04	29.81	− .06	72.2	+ 0.3	97	31	84	43	16	60	38	61	54	59	3.22	− 0.5	8	9,709	s.	52	s.	26	16	8	7	4.0	.....	.....
Amarillo	3,676	10	49	26.14	29.80	− .04	67.0	+ 2.7	98	31	82	35	1	52	43	54	45	55	0.89	− 2.8	2	9,585	sw.	37	sw.	9	26	4	1	2.6	.....	.....
Del Rio	944	64	71	28.85	29.82	− .03	77.9	+ 1.0	102	31	89	52	1	66	33	.....	.....	.....	1.90	− 0.5	7	9,348	se.	32	se.	24	15	11	5	3.8	.....	.....
Roswell	3,566	75	85	26.24	29.77	− .05	68.4	− 1.0	99	9	85	32	2	52	44	49	28	33	0.17	− 1.0	1	6,318	w.	35	nw.	20	23	7	1	1.9	.....	.....
Southern Plateau.							**64.5**	**− 1.4**										**31**	**0.10**	**− 0.2**										**1.6**		
El Paso	3,762	110	133	26.07	29.73	− .05	72.9	+ 0.8	97	9	86	39	1	60	36	49	22	21	0.43	+ 0.1	1	9,540	w.	43	w.	20	27	3	1	1.6	.....	.....
Santa Fe	7,013	57	66	23.18	29.74	− .07	55.6	− 1.1	81	9	68	30	2	43	33	41	25	36	0.07	− 1.0	2	6,874	sw.	33	sw.	24	19	9	3	3.3	T.	.....
Flagstaff	6,908	8	57	23.28	29.77	− .01	49.4	− 1.3	76	9	66	19	26	33	46	.....	.....	.....	0.37	.....	1	.....	sw.	51	sw.	24	27	4	0	.....	.....	.....
Phoenix	1,108	76	81	28.63	29.77	− .01	74.0	− 0.8	100	9	89	48	26	59	41	54	34	28	T.	0.0	0	4,337	e.	24	sw.	19	27	4	0	1.0	.....	.....
Yuma	141	9	54	29.62	29.77	− .02	75.5	− 1.3	103	8	94	50	26	57	44	57	42	38	0.00	0.0	0	4,053	w.	27	w.	19	31	0	0	0.3	.....	.....
Independence	3,910	11	42	25.86	29.80	− .04	59.8	− 4.7	86	5	77	28	24	42	44	.....	.....	.....	0.01	− 0.2	1	5,412	se.	36	n.	23	20	11	0	.....	.....	.....
Middle Plateau.							**53.5**	**− 3.0**										**38**	**0.50**	**− 0.6**										**3.4**		
Reno	4,532	74	81	25.41	29.90	− .01	52.0	− 1.6	82	3	66	27	13	38	42	40	26	43	T.	− 0.8	0	6,735	w.	52	sw.	6	23	3	5	2.7	T.	.....
Tonopah	6,090	12	20	23.98	29.84	.....	51.8	.....	77	4	64	22	24	40	34	38	21	34	0.26	− 1.1	4	7,669	nw.	36	nw.	19	18	9	4	3.5	0.7	.....
Winnemucca	4,344	18	56	25.54	29.92	+ .01	50.3	− 4.1	84	3	66	20	13	35	45	39	27	49	0.49	− 0.5	4	5,063	sw.	48	sw.	6	19	5	7	3.6	0.2	.....
Modena	5,479	10	43	24.51	29.81	− .01	51.7	− 2.8	80	4	69	21	14	35	47	38	20	36	0.62	− 0.2	2	9,825	sw.	59	s.	23	17	13	1	2.6	T.	.....
Salt Lake City	4,360	147	189	25.51	29.84	− .02	54.8	− 3.5	86	6	66	33	10	44	34	42	27	38	0.61	− 1.3	4	6,917	nw.	37	se.	24	15	7	9	4.5	.....	.....
Grand Junction	4,602	82	96	25.24	29.78	− .05	58.6	− 3.0	88	9	73	32	15	45	39	42	21	29	1.05	+ 0.1	3	6,655	nw.	49	sw.	24	16	10	5	3.8	.....	.....
Northern Plateau.							**51.9**	**− 5.0**										**58**	**1.50**	**− 0.2**										**6.0**		
Baker	3,471	48	53	26.40	29.99	+ .03	46.8	− 3.9	76	3	59	24	11	35	38	39	32	62	1.73	0.0	11	5,436	w.	29	nw.	24	7	17	7	5.2	1.4	.....
Boise	2,739	78	86	27.10	29.96	+ .02	52.5	− 5.1	81	6	65	25	11	40	37	42	30	50	1.80	+ 0.5	5	4,414	nw.	34	nw.	6	9	9	13	5.7	T.	.....
Lewiston	757	40	48	29.16	29.97	+ .01	55.4	− 5.4	82	2	67	33	12	44	39	.....	.....	.....	1.47	− 0.2	15	3,066	ne.	42	w.	6	5	9	17	6.8	.....	.....
Pocatello	4,477	46	54	25.37	29.88	− .01	49.4	− 6.1	81	6	61	24	12	38	36	39	26	46	1.12	− 1.1	9	7,393	sw.	58	sw.	6	7	12	12	6.0	0.2	.....
Spokane	1,929	101	110	27.91	29.96	.00	51.6	− 4.5	77	2	62	32	12	42	35	43	35	59	1.57	0.0	11	5,992	sw.	31	w.	6	3	11	17	7.0	T.	.....
Walla Walla	991	57	65	28.88	29.95	− .01	55.8	− 4.9	83	2	66	36	7	46	31	46	35	52	1.29	− 0.5	10	4,486	s.	28	sw.	6	8	13	10	5.6	T.	.....
North Pacific Coast Region.							**51.6**	**− 2.3**										**74**	**1.81**	**− 0.4**										**6.3**		
North Head	211	11	56	29.85	30.08	+ .05	48.4	− 2.8	57	24	52	38	10	45	11	47	44	86	2.34	0.0	19	12,028	nw.	74	se.	7	3	8	20	7.2	.....	.....
Seattle	125	215	250	29.94	30.07	+ .06	52.0	− 3.0	73	16	59	38	11	45	26	46	40	69	1.56	− 0.8	12	7,456	s.	43	s.	7	6	7	18	6.9	.....	.....
Tacoma	213	113	120	29.84	30.07	+ .05	51.8	− 2.7	76	2	60	34	11	44	31	46	41	71	1.10	− 1.4	11	5,237	sw.	27	sw.	7	6	12	13	6.5	T.	.....
Tatoosh Island	109	7	57	29.95	30.05	+ .04	48.5	− 1.1	63	24	52	38	8	44	15	46	44	87	3.58	− 0.5	14	8,162	s.	52	s.	6	13	6	12	5.1	0.1	.....
Medford	1,425	4	.....	.....	.....	.....	54.8	.....	85	2	69	28	11	40	44	.....	.....	.....	0.69	.....	9	.....	nw.	.....	.....	.....	12	9	10	.....	.....	.....
North Yakima	1,076	4	80	.....	.....	.....	56.0	.....	82	2	69	32	11	43	41	.....	.....	.....	0.13	.....	3	.....	nw.	.....	.....	.....	13	9	9	.....	.....	.....
Portland, Oreg.	153	68	106	29.91	30.06	+ .03	54.8	− 2.0	81	2	63	36	11	46	29	48	41	65	2.05	− 0.3	13	4,945	nw.	26	sw.	6	5	7	19	7.2	.....	.....
Roseburg	510	9	57	29.54	30.10	+ .07	54.2	− 1.8	83	1	66	34	12	43	40	47	40	66	2.05	0.0	12	2,828	nw.	27	sw.	8	8	16	7	5.1	.....	.....
Middle Pacific Coast Region.							**56.1**	**− 1.5**										**62**	**0.38**	**− 0.9**										**2.9**		
Eureka	62	73	89	30.05	30.12	+ .07	50.4	− 1.7	63	5	55	39	12	46	17	48	45	84	1.48	− 1.0	8	7,798	n.	43	n.	12	14	5	12	5.1	.....	.....
Mount Tamalpais	2,375	11	18	27.54	30.01	+ .01	53.8	+ 0.1	75	1	61	35	7	46	23	43	33	54	0.17	− 1.3	2	15,146	nw.	80	nw.	21	21	7	3	2.6	.....	.....
Point Reyes Light	490	7	18	29.46	29.98	.....	50.1	− 1.5	67	1	54	44	7	46	18	.....	.....	.....	0.19	.....	2	24,063	nw.	80	nw.	21	18	5	8	3.6	.....	.....
Red Bluff	332	50	56	29.60	29.95	.00	63.6	− 2.9	88	3	76	35	7	51	35	50	35	41	0.48	− 0.8	4	5,582	nw.	31	n.	12	16	12	3	2.8	.....	.....
Sacramento	69	106	117	29.89	29.96	+ .02	61.4	− 1.5	85	1	74	37	7	49	36	51	42	58	0.10	− 0.9	3	7,486	s.	32	nw.	12	27	4	0	1.3	.....	.....
San Francisco	155	209	213	29.84	30.01	+ .02	55.8	+ 0.3	79	1	63	46	7	49	29	49	44	71	0.07	− 0.7	1	8,346	sw.	34	sw.	5	23	5	3	2.4	.....	.....
San Jose	141	12	110	29.88	30.02	.....	57.4	− 3.3	87	1	70	35	7	44	38	.....	.....	.....	0.01	− 0.7	1	3,851	nw.	24	w.	30	22	8	1	2.2	.....	.....
South Pacific Coast Region.							**60.7**	**− 0.9**										**65**	**0.02**	**− 0.6**										**2.8**		
Fresno	327	89	98	29.59	29.94	+ .02	64.2	− 4.2	93	4	79	40	7	50	37	50	35	42	T.	− 0.6	0	7,750	nw.	39	nw.	6	25	6	0	1.8	.....	.....
Los Angeles	338	159	191	29.58	29.94	+ .01	61.3	+ 0.8	81	1	70	47	25	52	27	54	49	69	0.03	− 0.4	1	4,409	sw.	26	sw.	23	16	13	2	3.5	.....	.....
San Diego	87	62	70	29.85	29.94	− .01	60.8	0.0	72	2	66	50	26	56	18	55	52	75	0.01	− 0.4	1	5,460	nw.	24	w.	19	19	11	1	3.2	.....	.....
San Luis Obispo	201	32	40	29.81	30.03	+ .03	56.4	− 0.3	80	1	67	39	25	46	36	49	46	75	0.04	− 0.8	2	4,268	w.	24	w.	26	18	11	2	2.9	.....	.....
West Indies.																																
San Juan, P. R.	82	8	54	29.88	29.96	− .03	79.4	.....	90	26	85	70	3	74	18	.....	.....	.....	3.97	− 0.8	19	8,202	se.	31	ne.	3	11	16	4	4.9	.....	.....
Panama.																																
Balboa Heights	118	7	97	29.72	29.84	.....	79.6	.....	91	2	86	69	27	74	16	76	75	89	12.59	+ 3.7	20	4,610	nw.	31	ne.	25	1	9	21	8.2	.....	.....
Colon	25	5	71	29.81	29.84	.....	81.6	.....	90	11	87	72	27	76	14	77	76	88	9.38	+ 3.2	21	5,790	se.	31	nw.	26	0	14	17	7.8	.....	.....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during May, 1916, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	27	10:10 p. m.	D. N. p. m.	0.80	10:12 p. m.	10:31 p. m.	0.01	0.25	0.43	0.68	0.78										
Albany, N. Y.	8	5:12 p. m.	7:10 p. m.	0.62	5:40 p. m.	5:53 p. m.	.05	.19	.32	.39											
Alpena, Mich.	10	2:55 p. m.	5:00 p. m.	0.70	3:41 p. m.	3:54 p. m.	.20	.06	.32	.42											
Amarillo, Tex.	17			0.88														0.35			
Anniston, Ala.	21–23			2.91														.66			
Asheville, N. C.	22–23			3.02														.34			
Atlanta, Ga.	28	5:45 p. m.	7:25 p. m.	0.56	6:24 p. m.	6:48 p. m.	.04	.09	.27	.34	0.46	0.51									
Atlantic City, N. J.	25	4:44 p. m.	5:04 p. m.	0.49	4:47 p. m.	4:58 p. m.	.01	.13	.44	.48											
Augusta, Ga.	22–23			1.16														.37			
Baker, Oreg.	17–18			1.08														*			
Baltimore, Md.	4–5			1.27														.46			
Bentonville, Ark.	20			0.65														.43			
Binghampton, N. Y.	8	4:05 p. m.	4:42 p. m.	0.56	4:15 p. m.	4:25 p. m.	.03	.30	.49												
Birmingham, Ala.	21–22	4:40 p. m.	D. N. a. m.	12.91	10:19 p. m.	10:54 p. m.	.49	.05	.18	.31	.48	.61	0.67	0.72							
Bismarck, N. Dak.	13			0.72														*			
Block Island, R. I.	16–17			1.84														.46			
Boise, Idaho.	24–25			0.99														.40			
Boston, Mass	15–17			2.18														.57			
Buffalo, N. Y.	27			0.62														.44			
Burlington, Vt.	30	1:40 p. m.	3:15 p. m.	0.76	1:50 p. m.	2:19 p. m.	.08	.30	.46	.57	.64										
Cairo, Ill.	15	12:45 a. m.	D. N. a. m.	0.91	1:30 a. m.	1:51 a. m.	.14	.07	.20	.34	.48	.51									
Canton, N. Y.	16–19			3.01														*			
Charles City, Iowa.	13–14			2.14														.40			
Charleston, S. C.	30			0.42														.42			
Charlotte, N. C.	22–23	5:40 p. m.	12:50 p. m.	2.59	11:51 a.m.	12:31 p. m.	1.54	.05	.13	.24	.39	.61	.78	.89	0.98						
Chattanooga, Tenn	21–23			2.48														.48			
Cheyenne, Wyo.	19–20			1.18														.27			
Chicago, Ill.	14	3:47 p. m.	4:11 p. m.	0.33	3:48 p. m.	3:54 p. m.	.01	.30	.32												
Cincinnati, Ohio.	29	10:49 a. m.	4:25 p. m.	1.16	3:14 p. m.	3:23 p. m.	.47	.50	.63												
Cleveland, Ohio.	27			0.66														.32			
Columbia, Mo.	27			1.49														.62			
Columbia, S. C.	16			0.20														.17			
Columbus, Ohio.	25	10:01 a. m.	10:35 a. m.	0.39	10:07 a. m.	10:16 a. m.	.01	.18	.35												
Concord, N. H.	16–17			3.13														.28			
Concordia, Kans.	12	12:55 a. m.	7:17 a. m.	1.46	3:23 a. m.	3:48 a. m.	.52	.22	.17	.34	.44	.50									
	20	9:40 p. m.	11:15 p. m.	0.37	10:06 p. m.	10:29 p. m.	.06	.20	.37	.44	.52	.56									
Corpus Christi, Tex.	21			0.41														.40			
Davenport, Iowa.	13			1.08														.28			
Dayton, Ohio.	6–7			1.16														.50			
Del Rio, Tex.	15	2:38 p. m.	2:58 p. m.	0.79	2:40 p. m.	2:57 p. m.	.01	.48	.67	.76	.78										
Denver, Colo.	19			0.48														*			
Des Moines, Iowa.	28–29	11:30 p. m.	3:30 a. m.	0.60	12:01 a. m.	12:07 a. m.	.07	.27	.33												
Detroit, Mich.	27	6:15 a. m.	7:35 a. m.	0.83	6:26 a. m.	6:46 a. m.	.01	.12	.37	.50	.58										
Devils Lake, N. Dak.	30–31			0.75														.22			
Dodge City, Kans.	17			0.18														.12			
Dubuque, Iowa.	29	D.N. a. m.	1:07 p. m	0.63	5:16 a. m.	5:25 a. m.	.04	.31	.46												
Duluth, Minn.	13–15			1.27														.27			
Eastport, Me.	30–31			0.38														*			
Elkins, W. Va.	29	9:08 p. m.	D.N. p. m.	0.56	9:08 p. m.	9:22 p. m.	.00	.10	.31	.44											
El Paso, Tex.	1			0.43														.17			
Erie, Pa.	27			1.01														.47			
Escanaba, Mich.	14–15			1.21														.40			
Eureka, Cal.	5–6			0.66														.18			
Evansville, Ind.	15–16			1.29														*			
Flagstaff, Ariz.	19			0.37														*			
Fort Smith, Ark.	20–21	7:18 p. m.	12:04 a. m.	2.31	9:03 p. m.	9:55 p. m.	.09	.32	.62	.95	1.16	1.33	1.44	1.56	1.72	1.92	2.00	2.07			
Fort Wayne, Ind.	14			1.15														.47			
Fort Worth, Tex.	1–2			2.78														.45			
Fresno, Cal.	18			T.														T.			
Galveston, Tex.	18	D. N. a. m.	10:05 a. m.	1.67	6:19 a. m.	7:08 a. m.	0.04	0.16	0.51	0.74	0.84	0.91	0.93	0.97	1.14	1.22	1.26				
	21	2:15 p. m.	7:40 p. m.	6.13	2:26 p. m.		.01	.20	.36	.52	.58	.59	.60	.61	.63	.67	.72				
								.75	.78	.80	1.03	1.15	1.20	1.36	1.40	1.48	1.59				
								1.79	1.88	1.95	2.06	2.12	2.13	2.16	2.19	2.22	2.25				
								2.40	2.49	2.55	2.70	2.85	2.93	2.99	3.06	3.13	3.23				
								3.32	3.52	3.79	4.05	4.26	4.44	4.64	4.77	4.82	5.00				
						7:25 p. m.		5.17	5.26	5.42	5.54	5.65	5.75	5.83	5.91	6.04	6.09				
Grand Haven, Mich.	9–10			0.96														.59			
Grand Junction, Colo.	19–20			1.04														.19			
Grand Rapids, Mich.	29			0.80														.39			
Green Bay, Wis.	26	4:30 p. m.	6:25 p. m.	0.61	5:48 p. m.	6:10 p. m.	.09	.23	.35	.44	.50	.51									
Hannibal, Mo.	27	D.N. a. m.	D.N. a. m.	0.93	12:34 a. m.	12:50 a. m.	.01	.37	.60	.66	.69										
Harrisburg, Pa.	28	4:22 p. m.	4:45 p. m.	0.45	4:25 p. m.	4:38 p. m.	.01	.11	.38	.43											
Hartford, Conn.	29	D.N. a. m.	7:05 a. m.	0.79	1:44 a. m.	1:59 a. m.	.05	.25	.38	.45											
Hatteras, N. C.	5			0.65														.59			
Havre, Mont.	29–30			0.87														.39			
Helena, Mont.	23–25			1.22														*			
Houghton, Mich.	26	11:50 a. m.	6:55 p. m.	1.51	12:39 p. m.	1:08 p. m.	.03	.15	.23	.46	.65	.77	.89								
Houston, Tex.	2	10:43 a. m.	11:47 a. m.	0.89	11:02 a. m.	11:39 a. m.	.06	.12	.22	.32	.44	.54	.63	.74	.83						
	18	D.N. a. m.	8:20 a. m.	1.96	3:56 a. m.	4:29 a. m.	.05	.07	.19	.33	.56	.64	.76	.92							
					5:22 a. m.	5:45 a. m.	1.13	.05	.07	.24	.41	.46									
Huron, S. Dak.	20–21			1.46														.66			
Independence, Cal.	19			0.01														.01			
Indianapolis, Ind.	27			0.60														.53			
Iola, Kans.	26–27			0.98														.34			
Jacksonville, Fla.	23			1.49														.57			
Kalispell, Mont.	26			0.41														.13			
Kansas City, Mo.	26	10:05 p. m.	D. N. p. m.	0.99	10:52 p. m.	11:20 p. m.	.01	.12	.30	.45	.67	.90	.96								
	27	5:52 a. m.	8:55 a. m.	1.68	6:05 a. m.	6:32 a. m.	.02	.13	.31	.41	.61	.93	.97								
Keokuk, Iowa.	26	8:00 p. m.	9:23 p. m.	0.88	9:12 p. m.	9:22 p. m.	.29	.29	.58												
Key West, Fla.	12	5:40 p. m.	9:35 p. m.	1.18	7:35 p. m.	8:00 p. m.	.40	.06	.18	.33	.44	.53									
Knoxville, Tenn.	21–23			2.70														*			
La Crosse, Wis.	13–14			1.18														*			
Lander, Wyo.	20			0.73														.25			
Lansing, Mich.	29			1.04														.47			
Lewiston, Idaho.	18–19			0.75														.12			
Lexington, Ky.	29–30			1.11														.25			
Lincoln, Nebr.	12–14			2.48														.57			
Little Rock, Ark.	29			0.32														.29			

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during May, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Los Angeles, Cal	19			0.03														0.03			
Louisville, Ky	29–30			1.58														.35			
Ludington, Mich	8	D. N. a. m.	D. N. a. m.	0.64	12:30 a. m.	12:47 a. m.	T.	0.36	0.48	0.53	0.57										
Lynchburg, Va	4	2:00 p. m.	6:40 p. m.	1.68	2:12 p. m.	2:49 p. m.	0.01	.07	.09	.24	.51	0.75	1.01	1.33	1.38						
Macon, Ga	30	3:57 p. m.	4:20 p. m.	0.38	4:00 p. m.	4:12 p. m.	.02	.08	.28	.36											
Madison, Wis	7			0.33														.31			
Marquette, Mich	10			0.23														.22			
Memphis, Tenn	21	D. N. a. m.	10:10 a. m.	1.59	4:18 a. m.	4:30 a. m.	.21	.13	.29	.35											
Meridian, Miss	21–22	1:05 p. m.	5:30 a. m.	3.94	7:31 p. m.	8:12 p. m.	1.26	.08	.17	.31	.50	.69	.90	1.01	1.29	1.32					
Miami, Fla	19	11:57 a. m.	3:22 p. m.	1.33	12:01 p. m.	12:35 p. m.	.02	.12	.27	.42	.62	.75	.89	.95							
	28	11:10 a. m.	12:28 p. m.	0.70	11:36 a. m.	12:15 p. m.	.07	.07	.17	.27	.35	.38	.43	.53	.62						
Milwaukee, Wis	21			0.73														.33			
Minneapolis, Minn	25	2:45 a. m.	7:50 a. m.	1.76	3:11 a. m.	3:56 a. m.	.09	.05	.15	.23	.25	.26	.35	.52	.62	.78					
					6:30 a. m.	6:58 a. m.	.98	.13	.21	.26	.35	.58	.64								
Mobile, Ala	16	D. N. a. m.	6:25 p. m.	1.97	1:00 a. m.	1:25 a. m.	.04	.18	.51	.72	.81	.87									
					2:54 a. m.	3:18 a. m.	1.36	.10	.23	.29	.42	.50									
Modena, Utah	19–20			0.62														.15			
Montgomery, Ala	21–23	6:40 p. m.	D. N. a. m.	2.06	10:50 p. m.[1]	11:10 p. m.[1]	1.54	.17	.25	.31	.42										
Moorhead, Minn	31			1.44														.51			
Mount Tamalpais, Cal	6			0.15														.07			
Nantucket, Mass	28	1:40 p. m.	7:20 p. m.	0.51	2:41 p. m.	2:54 p. m.	.10	.09	.31	.38											
Nashville, Tenn	29–30	10:30 p. m.	D. N. a. m.	1.42	11:09 p. m.	11:36 p. m.	.02	.18	.42	.55	.62	.70	.75								
New Haven, Conn	14–17			1.89														.51			
New Orleans, La	21	8:15 a. m.	12:15 p. m.	1.90	10:12 a. m.	10:44 a. m.	.15	.11	.20	.40	.86	1.23	1.52	1.59							
	21–22	10:25 p. m.	6:30 a. m.	2.40	10:45 p. m.	11:37 p. m.	.12	.05	.10	.27	.58	.74	.93	1.08	1.31	1.44	1.55	1.63			
New York, N. Y	14–17			2.35														.48			
Norfolk, Va	23–24	1:55 p. m.	9:50 a. m.	2.46	12:31 a. m.	1:09 a. m.	.92	.08	.13	.24	.34	.41	.57	.66	.71						
Northfield, Vt	16–18			2.54														.25			
North Head, Wash	5–7			0.72														.70			
North Platte, Nebr	19–21			1.67														.28			
Oklahoma, Okla	27			0.18														.11			
Omaha, Nebr	31	7:35 p. m.	8:30 p. m.	0.84	7:49 p. m.	8:23 p. m.	.04	.08	.16	.29	.40	.49	.66	.79							
Oswego, N. Y	16–17			2.20														.47			
Palestine, Tex	1	5:55 a. m.	11:45 a. m.	1.30	6:06 a. m.	6:50 a. m.	.01	.22	.32	.43	.52	.58	.62	.67	.70	.76					
	20–21	9:50 p. m.	11:45 a. m.	2.55	5:39 a. m.	6:31 a. m.	1.05	.06	.11	.17	.24	.34	.39	.41	.52	.66	.77	.82			
Parkersburg, W. Va	28	1:30 p. m.	2:08 p. m.	0.49	1:44 p. m.	1:54 p. m.	.02	.27	.40												
Pensacola, Fla	22	4:15 a. m.	8:10 p. m.	4.39	4:52 a. m.	5:19 a. m.	.15	.15	.32	.41	.49	.63	.68								
	30	6:15 p. m.	7:20 p. m.	0.69	6:35 p. m.	7:07 p. m.	.11	.08	.19	.24	.39	.46	.51	.56							
Peoria, Ill	27	12:35 a. m.	5:50 a. m.	1.09	1:03 a. m.	1:29 a. m.	.04	.08	.18	.27	.44	.55	.59								
Philadelphia, Pa	25	4:15 p. m.	6:10 p. m.	1.01	4:38 p. m.	4:52 p. m.	.02	.37	.80	.97											
Phoenix, Ariz	19			T.														T.			
Pierre, S. Dak	28	1:20 p. m.	2:45 p. m.	0.58	1:56 p. m.	2:21 p. m.	.03	.09	.20	.26	.46	.53									
Pittsburgh, Pa	30			0.53														.25			
Pocatello, Idaho	25			0.32														.21			
Point Reyes Light, Cal	5–6			0.19														.06			
Port Huron, Mich	27	3:00 a. m.	5:00 a. m.	0.76	3:50 a. m.	4:14 a. m.	.05	.12	.25	.39	.48	.59									
Portland, Me	16–17			4.89														.68			
Portland, Oreg	21–22			0.31														.12			
Providence, R. I	16–17			2.09														.69			
Pueblo, Colo	14			0.53														.25			
Raleigh, N. C	15–16	8:16 p. m.	9:10 a. m.	1.64	2:17 a. m.	2:56 a. m.	.46	.07	.13	.21	.29	.44	.55	.67	.75						
Rapid City, S. Dak	20–21			1.51														.21			
Reading, Pa	22–23			1.27														*			
Red Bluff, Cal	6			0.21														.19			
Reno, Nev	6, 16, 18, 23, 24, 27			T.														T.			
Richmond, Va	29	8:11 p. m.	9:30 p. m.	0.85	8:37 p. m.	8:52 p. m.	.01	.18	.62	.76											
Rochester, N. Y	16–17	2:33 p. m.	12:15 a. m.	2.11	3:48 p. m.	3:58 p. m.	.19	.19	.34												
Roseburg, Oreg	5			0.44														.11			
Roswell, N. Mex	1			0.17														.05			
Sacramento, Cal	24			0.05														.04			
Saginaw, Mich	29			0.63														.38			
St. Joseph, Mo	12–13	2:55 p. m.	D. N. a. m.	1.47	8:44 p. m.	9:27 p. m.	.42	.09	.27	.38	.48	.53	.62	.78	.93						
St. Louis, Mo	27–28			1.51														.53			
St. Paul, Minn	25	3:00 a. m.	7:35 a. m.	1.27	3:39 a. m.	4:07 a. m.	.07	.06	.19	.35	.41	.46	.51								
					7:01 a. m.	7:31 a. m.	.73	.09	.20	.31	.36	.46	.54								
Salt Lake City, Utah	19			0.36														.29			
San Antonio, Tex	2	4:20 a. m.	8:33 a. m.	0.81	4:20 a. m.	5:10 a. m.	.00	.09	.13	.17	.27	.32	.35	.38	.44	.61	.76				
	17–18	5:00 p. m.	5:50 a. m.	1.17	3:35 a. m.	4:19 a. m.	.11	.15	.37	.52	.64	.72	.76	.81	.85	.96					
	20–21	10:30 p. m.	6:00 a. m.	1.29	4:59 a. m.	5:34 a. m.	.01	.15	.53	.85	1.05	1.12	1.21	1.26							
San Diego, Cal	19			0.01														.01			
Sand Key, Fla	12	7:05 p. m.	9:35 p. m.	0.91	7:53 p. m.	8:20 p. m.	.04	.10	.19	.34	.44	.62	.68								
	28	6:20 a. m.	9:23 a. m.	0.86	7:39 a. m.	8:03 a. m.	.07	.20	.39	.50	.57	.68									
Sandusky, Ohio	27	8:10 a. m.	11:10 a. m.	0.68	8:38 a. m.	9:07 a. m.	.02	.05	.10	.13	.27	.45	.49								
San Francisco, Cal	6			0.07														.06			
San Jose, Cal	18			0.01														.01			
San Luis Obispo, Cal	6			0.02														.02			
Santa Fe, N. Mex	1–2			0.07														*			
Sault Ste. Marie, Mich	26			0.88														*			
Savannah, Ga	23	9:06 a. m.	12:08 p. m.	1.20	9:20 a. m.	9:49 a. m.	.01	.26	.59	.79	.86	.99	1.13								
Scranton, Pa	27–28			0.58														.27			
Seattle, Wash	21			0.37														.15			
Sheridan, Wyo	19–20			0.48														.36			
Shreveport, La	1	9:15 a. m.	1:00 p. m.	0.88	9:19 a. m.	9:34 a. m.	.01	.08	.25	.40											
Sioux City, Iowa	14			1.27														.51			
Spokane, Wash	26			0.19														.14			
Springfield, Ill	24	7:50 a. m.	10:05 a. m.	0.62	9:06 a. m.	9:18 a. m.	.04	.26	.48	.53											
Springfield, Mo	27			0.61														.33			
Syracuse, N. Y	15–17			2.62														.65			
Tocoma, Wash	6–7			0.53														.18			
Tampa, Fla	13–14			1.24														.20			
Tatoosh Island, Wash	5–7			1.86														.31			
Taylor, Tex	1	D. N. a. m.	6:05 a. m.	1.02	4:26 a. m.	4:55 a. m.	.04	.33	47	.59	.68	.78	.85								
	20–21	D. N. p. m.	11:04 a. m.	2.88	10:56 p. m.	11:26 p. m.	.03	.08	.19	.38	.53	.71	.82								
					4:31 a. m.	5:21 a. m.	1.47	.16	.21	.43	.54	.63	.68	.75	.81	.89	.94				
Terre Haute, Ind	28–29	10:55 p. m.	10:18 a. m.	1.40	6:11 a. m.	6:31 a. m.	.55	.05	.20	.30	.42										
Thomasville, Ga	8	6:50 p. m.	7:35 p. m.	0.39	7:14 p. m.	7:24 p. m.	.04	.23	.34												

[1] June 22.

* Self-register not working.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during May, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Toledo, Ohio	27			0.64														0.40			
Tonopah, Nev	18-19			0.17														.08			
Topeka, Kans	27	4:33 a. m.	7:40 a. m.	1.31	4:38 a. m.	5:15 a. m.	0.01	0.14	0.34	0.47	0.58	0.63	0.69	0.73	0.79						
Valentine, Nebr	23-24	9:45 p. m.	5:20 a. m.	1.56	1:36 a. m.	1:50 a. m.	.01	.19	.42	.50											
Vicksburg, Miss	2	2:49 p. m.	D. N. p. m.	2.97	6:36 p. m.	7:11 p. m.	1.28	.18	.42	.58	.71	.80	.87	.95							
	21	12:03 p. m.	6:10 p. m.	2.70	3:00 p. m.	4:35 p. m.	.90	.09	.12	.20	.28	.36	.40	.44	.46	0.59	0.71	.75	1.05	1.58	
Walla Walla, Wash	6			0.27														.15			
Washington, D. C	28			0.44														.35			
Wichita, Kans	13-14	8:25 p. m.	D. N. a. m.	2.24	10:13 p. m.	10:58 p. m.	.13	.08	.10	.20	.28	.39	.51	.60	.67	.72					
					12:19 a. m.	1:01 a. m.	1.19	.11	.40	.52	.59	.72	.81	.87	.96	1.03					
	28	6:23 p. m.	7:15 p. m.	1.19	6:25 p. m.	6:53 p. m.	.01	.06	.40	.80	.97	1.07	1.14								
Williston, N. Dak	30			0.37														.19			
Wilmington, N. C	16	3:20 p. m.	5:05 p. m.	1.57	3:29 p. m.	4:19 p. m.	.04	.09	.23	35	45	.66	.94	1.10	1.21	1.26	1.31				
Winnemucca, Nev	25			0.09														.06			
Wytheville, Va	22-23			1.21														.21			
Yankton, S. Dak	13-14			1.48														.40			
Yellowstone Park, Wyo	23-25			0.68														*			

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, May, 1916.*

Stations.	Altitude above M. S. L.* Jan. 1, 1916.	Pressure. Station reduced to mean of 24 hours.	Pressure. Sea level reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Mean maximum.	Temperature of the air. Mean minimum.	Temperature of the air. Highest.	Temperature of the air. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	°F.	°F.	°F.	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
St. John's, N. F	125	29.61	29.75	−0.23	44.2	+1.3	50.4	38.0	66	34	7.10	+3.44	T.
Sydney, C. B. I	48	29.84	*29.88*	− *.09*	46.0	+0.8	55.9	36.1	68	30	1.98	−1.79	
Halifax, N. S	80	29.77	*29.88*	− *.10*	48.4	0.0	58.0	38.9	72	30	3.85	−0.41	
Yarmouth, N. S	65	29.80	29.87	− .11	46.4	−1.2	53.3	39.5	62	32	2.53	−1.27	
Charlottetown, P. E. I	38	29.82	29.86	− .10	47.0	+0.1	54.0	40.0	64	32	1.99	−0.92	
Chatham, N. B	28	29.84	*29.86*	− *.09*	50.9	+2.4	61.2	40.6	76	32	3.50	+0.29	
Father Point, Que	20	29.80	29.82	− .11	45.9	+1.9	52.5	39.4	70	29	3.96	+1.38	
Quebec, Que	296	29.52	29.83	− .11	51.0	+1.1	59.7	42.4	79	31	6.73	+3.65	
Montreal, Que	187	29.64	29.84	− .10	55.0	+0.3	63.4	46.7	81	35	4.98	+2.03	
Stonecliffe, Ont	489	29.25	*29.86*	− *.07*	50.6	−1.7	61.9	39.4	83	27	4.06	+1.55	
Ottawa, Ont	236	29.59	*29.85*	− *.09*	54.0	−0.9	62.8	45.2	80	33	7.04	+4.45	0.3
Kingston, Ont	285	29.58	29.89	− .07	52.1	−0.8	60.0	44.2	70	36	6.95	+4.27	
Toronto, Ont	379	29.49	*29.90*	− *.08*	54.3	+1.1	63.8	44.8	81	37	5.58	+2.54	
White River, Ont	1,244	28.49	*29.80*	− *.15*	44.1	−1.6	55.6	32.6	71	20	2.32	+0.37	2.4
Port Stanley, Ont	592	29.28	29.92	− .05	53.0	−0.1	61.5	44.5	78	33	6.90	+3.72	
Southampton, Ont	656	29.19			49.9	−0.8	59.0	40.8	76	31	4.22	+1.78	
Parry Sound, Ont	688	29.18	29.88	− .07	50.5	−0.6	60.0	41.0	78	31	5.71	+2.78	
Port Arthur, Ont	644	29.11	29.82	− .14	47.0	+1.1	57.0	37.0	75	27	3.47	+1.32	
Winnipeg, Man	760	28.99	29.82	− .14	49.6	−2.0	61.4	37.8	75	24	2.47	+0.19	
Minnedosa, Man	1,690	28.01	29.81	− .15	48.6	+0.2	59.8	36.6	76	20	1.58	+0.13	0.4
Qu'Appelle, Sask	2,115	27.55	29.78	− .16	47.7	−2.1	58.8	36.6	76	22	3.15	+1.50	0.4
Medicine Hat, Alberta	2,144	27.54	*29.81*	− *.08*	51.7	−2.4	64.7	38.7	93	26	3.73	+2.42	
Swift Current, Sask	2,392	27.24	*29.80*	− *.12*	48.0	−2.7	60.9	35.2	79	23	1.59	−0.17	6.1
Calgary, Alberta	3,428	26.34	*29.86*	− *.02*	46.3	−2.7	58.3	34.3	74	23	3.10	+1.33	2.2
Banff, Alberta	4,521	25.30	*29.88*	*.00*	41.5	−5.5	51.4	31.6	64	25	4.24	+2.20	29.7
Edmonton, Alberta	2,150	27.56	*29.83*	− *.05*	48.6	−2.2	61.0	36.3	75	27	1.77	+0.22	2.2
Prince Albert, Sask	1,450	28.27	*29.83*	− *.12*	47.8	+0.2	59.0	36.7	78	20	4.38	+3.12	
Battleford, Sask	1,592	28.09	*29.81*	− *.11*	48.1	−2 9	60.3	35.9	77	21	2.77	+1.15	
Kamloops, B. C	1,262	28.66	29.94	+ .05	56.3	−2.8	68.1	44.4	82	35	0.58	−0.66	
Victoria, B. C	230	29.78	30.03	+ .03	50.7	−1.8	57.4	43.9	67	36	0.89	−0.59	
Barkerville, B. C	4,180	25.63	29,94	+0.10	41.9	−3.6	53 1	30.7	67	23	1.54	−0.98	
Hamilton, Bermuda	151	29.92	30.08	+0.02	67.8	−1.6	73 3	62.3	78	55	1.66	−3.00	

* The altitudes given above were furnished by the Director of the Canadian Meteorological Service, Mar. 9, 1916, and refer to cisterns of barometers at the respective stations. Where sea-level pressures and departures are *italicized* new reduction factors are in course of computation.—C. A., Jr.

Chart I. Hydrographs of Several Principal Rivers, May, 1916.

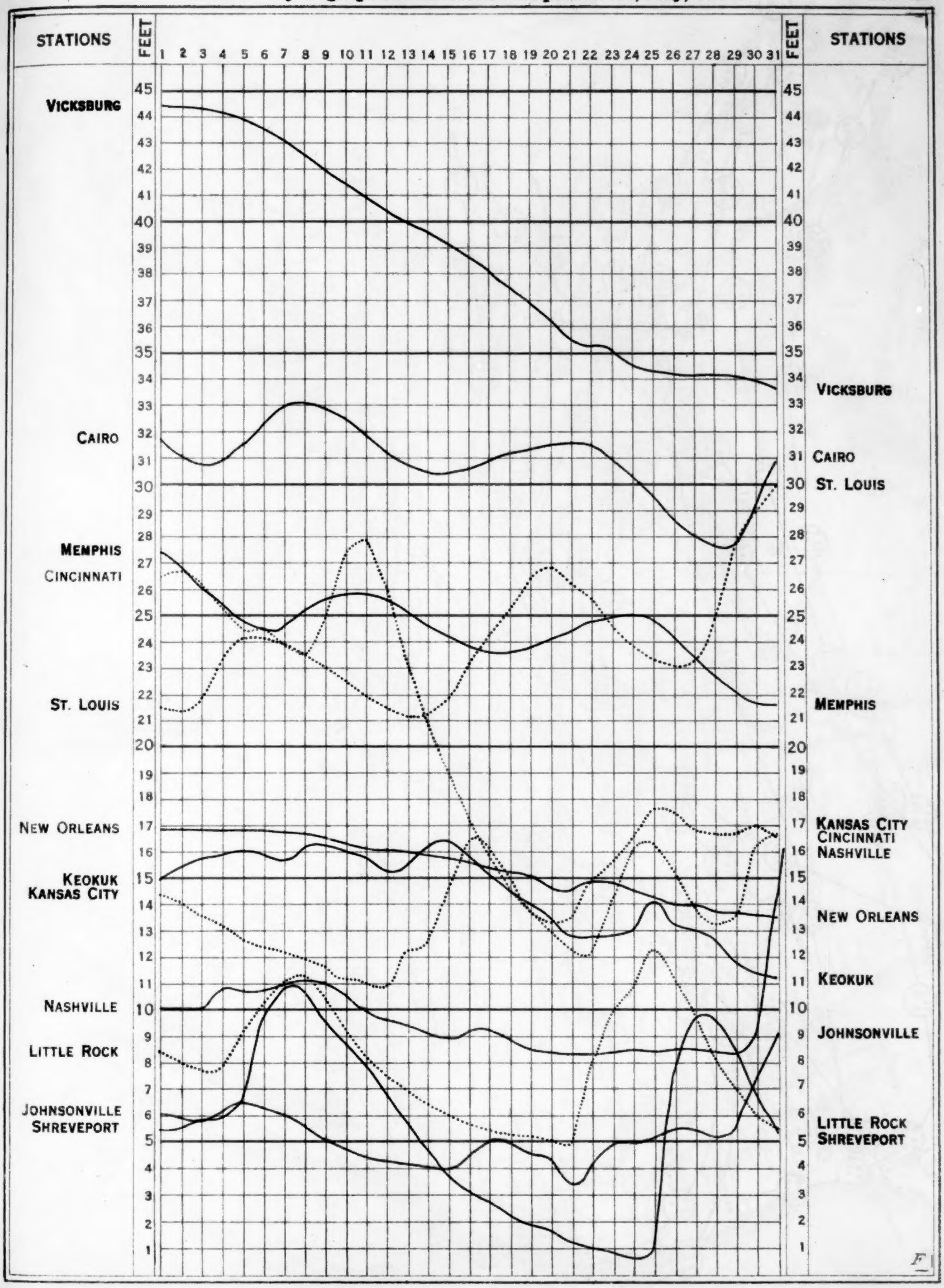

Chart II. Tracks of Centers of High Areas, May, 1916.

(Plotted by R. H. Weightman.)

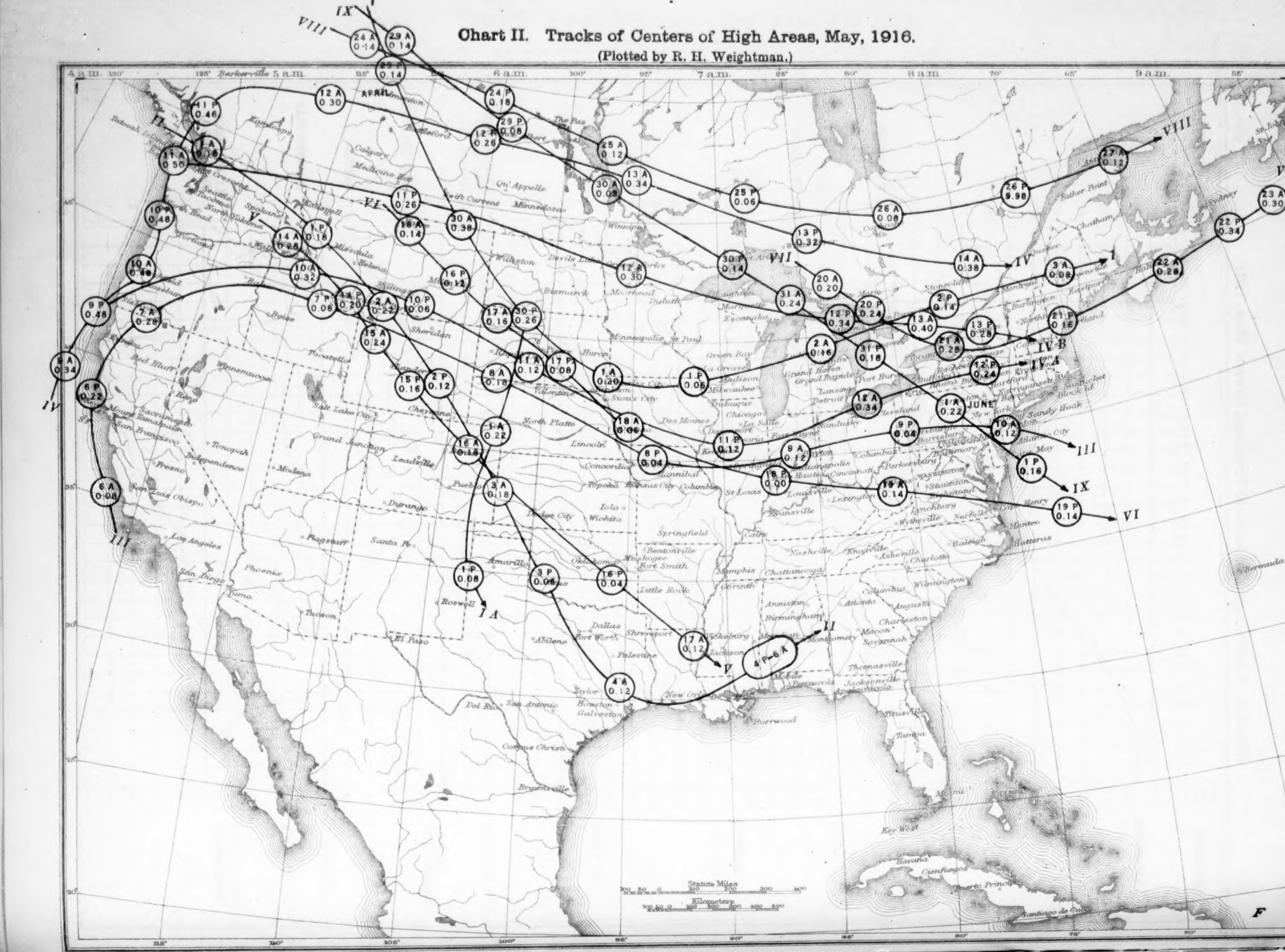

Chart III. Tracks of Centers of Low Areas, May, 1916.

(Plotted by R. H. Weightman.)

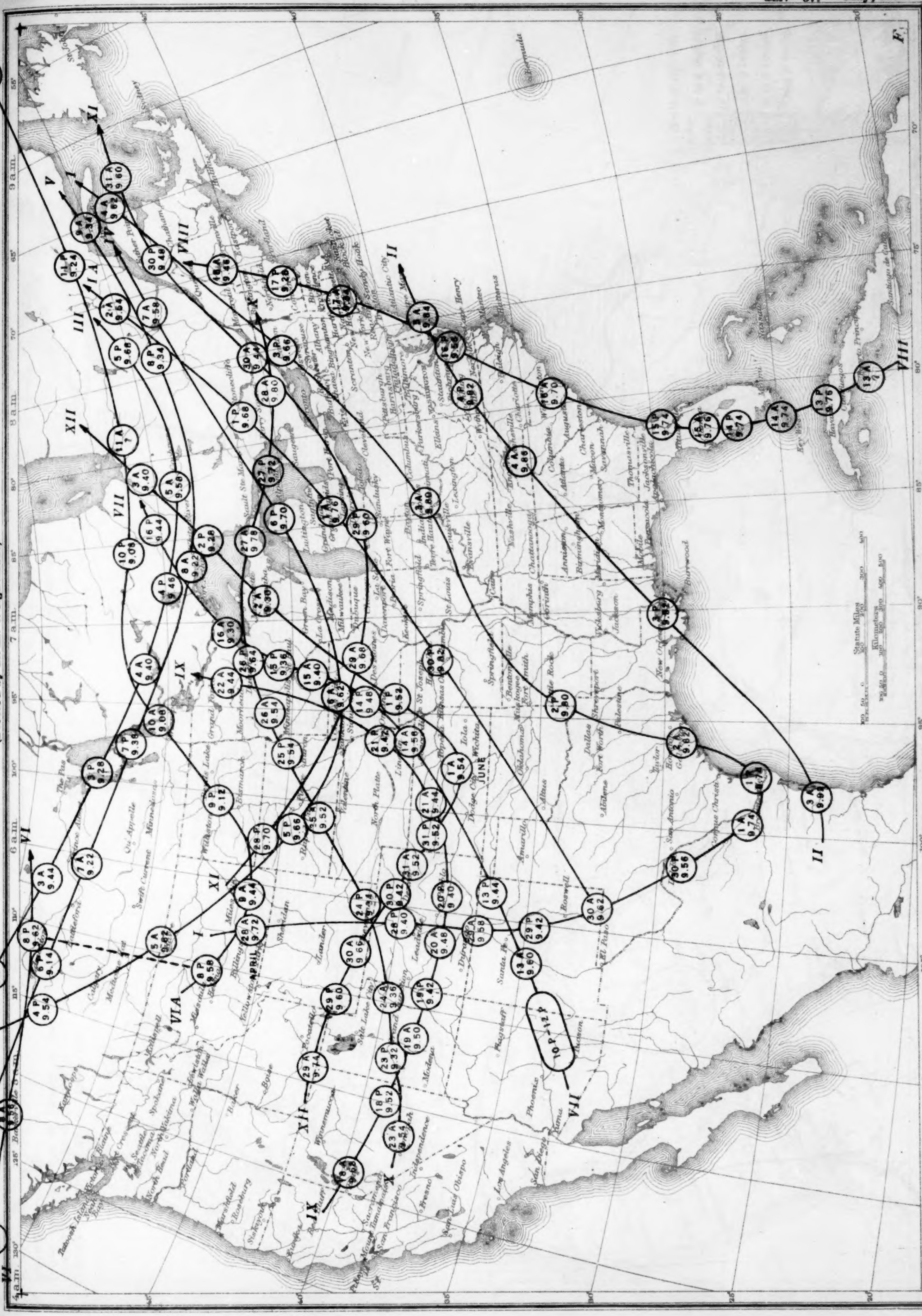

Chart III. Tracks of Centers of Low Areas, May, 1916.
(Plotted by R. H. Weightman.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, May, 1916.

Chart V. Total Precipitation, May, 1916.

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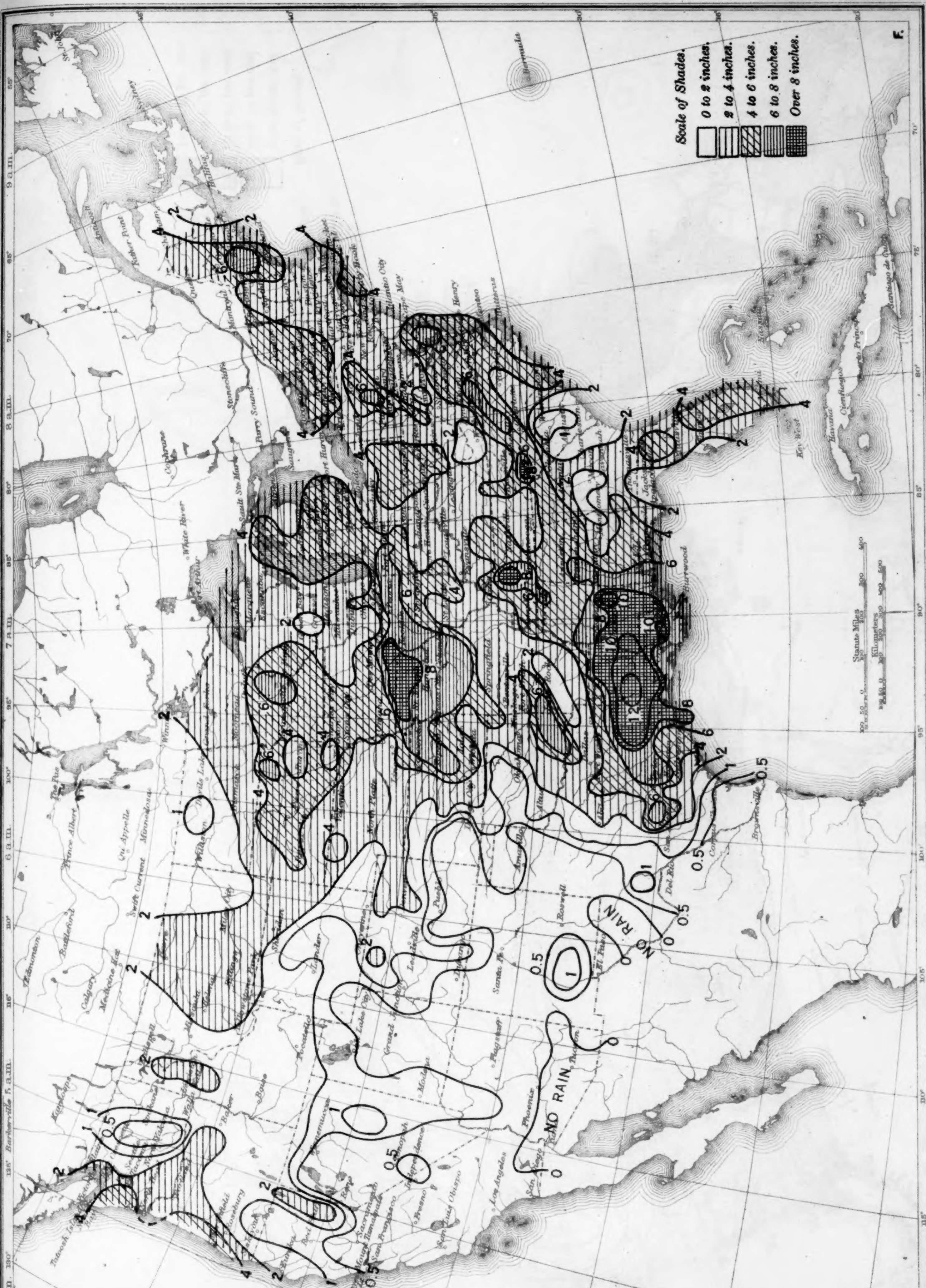

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, May, 1916.

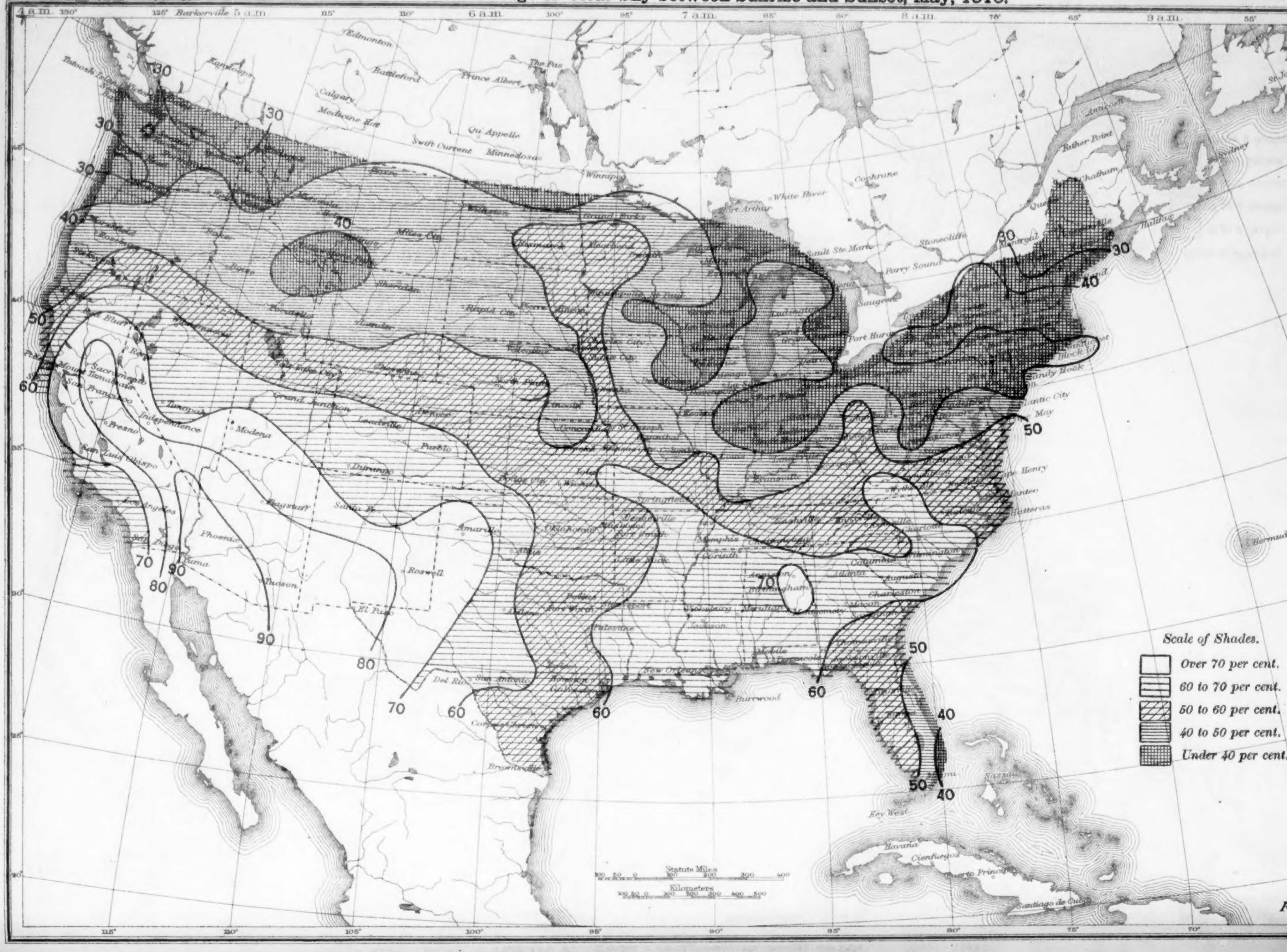

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, May, 1916.

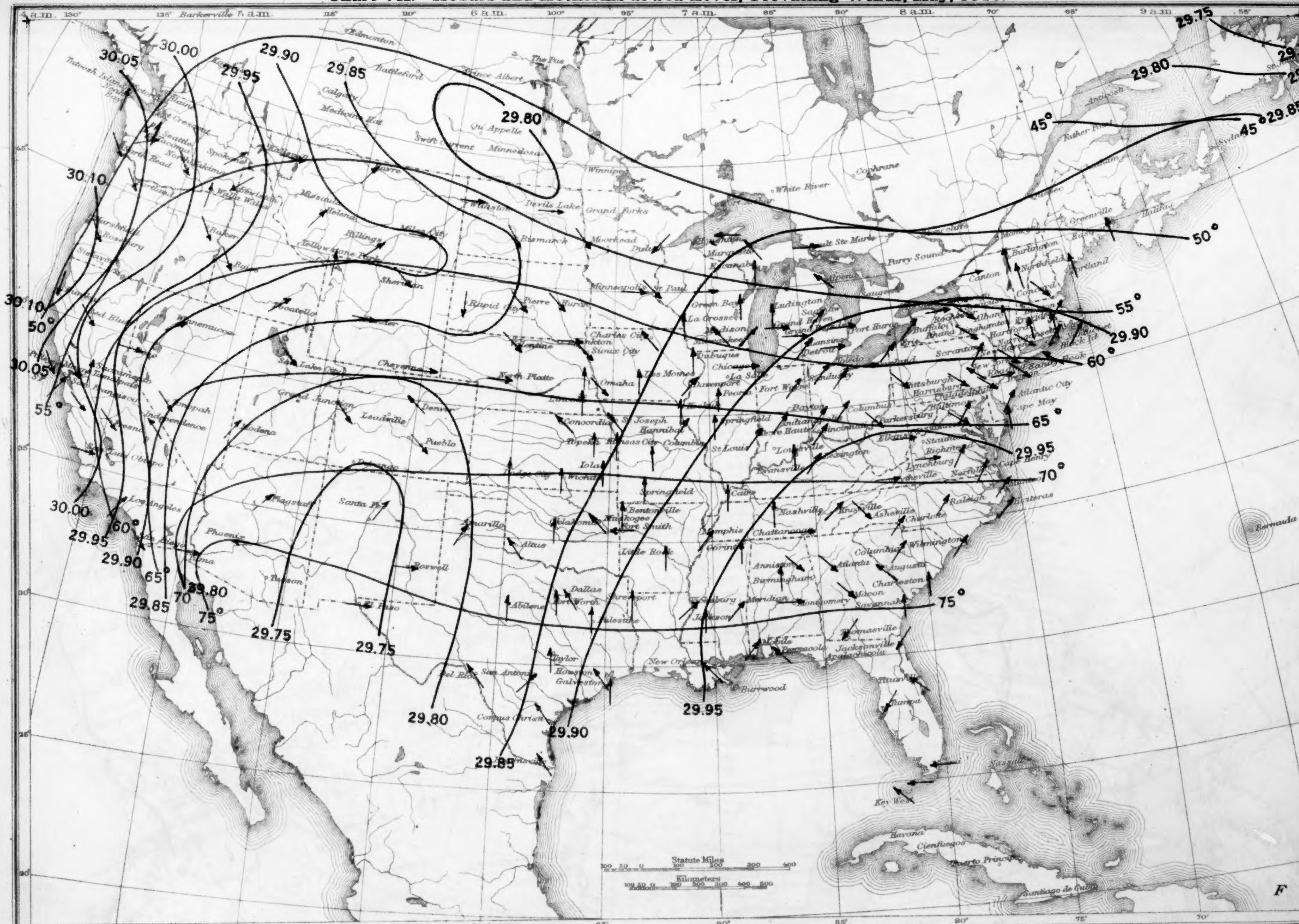

Chart VIII. Total Snowfall, Inches, May, 1916.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, May, 1915.

(Plotted by F. A. Young.)

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